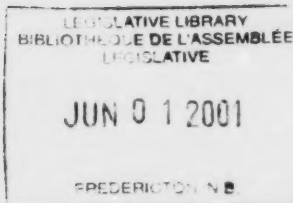
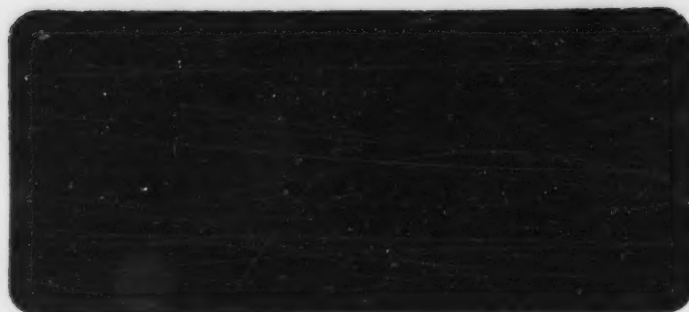




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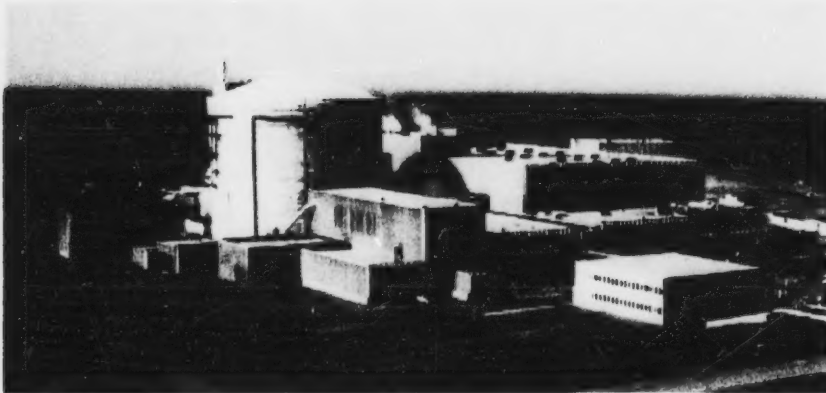
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POINT LEPREAU GENERATING STATION

**Environmental Radiation
Monitoring Data**

January 1, 2000 to December 31, 2000



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Executive Summary

This annual report is a compilation of the 2000 results from the Environmental Radiation Monitoring Program for the Point Lepreau Generating Station (PLGS).

Since 1976, the monitoring program has analysed more than 25 000 samples to define background radiation from natural and human sources. The contribution from human sources has declined significantly since atmospheric bomb tests have ceased. The program detected radionuclide fallout in New Brunswick after a Chinese atmospheric bomb test in 1980, and fallout from the accident at Chernobyl in 1986. There have been no regionally detectable releases of radiation from any human activity since these two events.

In 2000, there were 1900 analyses on 1399 samples to monitor environmental radiation around Point Lepreau and across the province in general. The analyses indicate that radiation dose from PLGS emissions continues to be well below the public dose limit (1000 microsieverts per annum), and also well below the operating target for nuclear power facilities in Canada (50 microsieverts per annum).

The only assessable radiation dose from PLGS on the local population is that from tritiated water vapour in air. As in past years, tritium continues to be detected offsite in air and water samples. The only trend that was obvious from the historical data, and continued in 2000, was increasing H-3 in Parshall Flume water from the SRWMF-Phase 1.

<i>Source of Dose to Critical Group</i>	<i>Individual Dose (μSv/a)</i>
PLGS airborne emissions	0.38
PLGS liquid emissions	0.21
natural background (estimate)	2000

The program was revised in late 1999, with changes being phased in during 2000. The most dramatic change was in the area of Quality Assurance. There were 431 analyses performed on 348 QA samples.

The new objectives of the program were met.

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1 Introduction

The licence to operate PLGS, issued by the Canadian Nuclear Safety Commission (CNSC), requires that NB Power maintain an Operational Environmental Radiation Monitoring Program (OERMP) during normal plant operations. This document describes the results of the program for the year 2000.

The requirement for this program is stated in *Radiation Protection Directives*⁽¹⁾ and *Solid Radioactive Waste Management Facility 1993 Safety Report*⁽²⁾. The underlying reason for this is the large inventory of radionuclides that exist on site. The program operates in conjunction with *Liquid and Gaseous Effluent Monitoring Program*⁽³⁾, which monitors and controls effluents at their source. The Derived Emission Limits (DELs) are calculated in *Derived Emission Limits for Radionuclides in Airborne and Liquid Effluents*⁽⁴⁾.

Monitoring of the site began in 1976 with the Pre-operational Program⁽⁵⁾, which became the OERMP in 1982⁽⁶⁾. This was implemented when PLGS was declared "in-service" in February, 1983. All radionuclide analyses in 2000 were performed in the Health Physics Environmental/Dosimetry Laboratory at 420 York Street, Fredericton, NB by the three full-time staff members (Health Physicist, Senior Technical Specialist and Technical Specialist).

The radiation monitoring program for PLGS is reviewed annually. This ensures that the samples collected, their frequency of collection, and the analytical techniques used are appropriate to achieve the objectives of the program. Late in 1999, the basis of the OERMP was extensively revised⁽⁷⁾ to comply with *Guidelines for Radiological Monitoring of the Environment*⁽⁸⁾, which did not exist when this program was first implemented. Although the document describing the revised program was issued in January, 2000, the implementation for some aspects of the program was not complete until later on in the year.

The Environmental Radiation Monitoring Program for PLGS fulfils several objectives. These are to:

- 1) permit the estimation of dose to critical groups and populations from the radioactive emissions from PLGS and its Solid Radioactive Waste Management Facility (SRWMF). This is achieved through the analyses of environmental and effluent samples.
- 2) provide data to confirm compliance of PLGS and the SRWMF with release guidelines and regulations and to provide public assurance of compliance. This is achieved through the issuance of the annual report to all interested parties.
- 3) establish and maintain the capability for environmental monitoring so that an effective response can be made to emergency conditions. This is achieved by maintaining the resources to step up the monitoring program during increased emissions that are only likely during an accident. The ability to interpret the data and make recommendations is also maintained.

- 4) maintain a database to facilitate the detection of trends. This is achieved by storing all results on a computer system that has the capability of reporting and graphing any desired subsets of the data.
- 5) verify or refine environmental models used in the calculation of Derived Emission Limits (DELs). This is achieved by comparing the theoretical dispersion factor with one calculated empirically. As well, other exposure routes to the public are continually evaluated.
- 6) determine the fate of released radioactive materials to show whether any significant pathway to humans has been overlooked. This is achieved through the collection and analysis of sample media outside of the established program. As well, any results that are not consistent with effluent results are investigated.

The capability of the radiation monitoring laboratory is assessed through the QA program. Analytical checks are also conducted daily. Indicator radionuclides, for example K-40 in milk, seawater and other samples, show that the analyses are reproducible and that the operation of the laboratory has not changed significantly since it began.

The following sections will briefly describe the program. Details are provided on PLGS emissions, analyses results, trends, dose estimates, and the quality assurance program.

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2 Point Lepreau Emission Data

Table 2.01 lists the production performance for PLGS since its beginning. Experience has shown that the years of lower capacity factors are usually the years with the lowest airborne emissions of most radionuclides, especially noble gases. The opposite is true for liquid emissions.

Table 2.01: PLGS Production Performance

<i>Year</i>	<i>Annual Gross Capacity Factor (%)</i>
1983	86
1984	90
1985	97
1986	94
1987	92
1988	96
1989	95
1990	96
1991	98
1992	87
1993	95
1994	94
1995	29
1996	83
1997	62
1998	68
1999	74
2000	71
Lifetime (Since In-service)	83.8

Emissions from PLGS continue to be at low levels as indicated in Table 2.02. By the time these releases reach the edge of the exclusion zone, they are diluted below the detection limits of most analytical procedures. Laboratory staff monitor the results of the emissions programs so that adjustments can be made to sampling and analysis protocols. There were no unusual emissions during the year 2000.

In the year 2000, the DEL changed for Kr-85, I-131 and I-133 in the airborne pathway and I-131 and I-133 in the liquid pathway to match CNSC limits.

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In the year 2000, the DEL changed for Kr-85, I-131 and I-133 in the airborne pathway and I-131 and I-133 in the liquid pathway to match CNSC limits.

Table 2.02: Radionuclides Detected in Effluents

Nuclide	Gaseous Effluent DEL (Bq/a)	Release (Bq)	Liquid Effluent DEL (Bq/a)	Release (Bq)
H-3	4.3E+17	1.3E+14	1.6E+19	9.6E+13
C-14	3.3E+15	2.3E+11	3.0E+14	1.7E+09
Na-24	5.6E+15		-----	
Ar-41	6.4E+16	3.7E+12	-----	
Sc-46	1.7E+14		-----	
Cr-51	2.4E+16		2.2E+15	3.6E+07
Mn-54	1.1E+14		6.4E+13	2.3E+06
Fe-55	-----		5.1E+14	
Fe-59	4.0E+14		3.1E+13	7.4E+06
Co-58	3.0E+14		7.5E+13	
Co-60	6.5E+12	1.1E+06	1.8E+13	2.6E+08
Zn-65	7.1E+13		1.5E+13	
As-76	-----		3.2E+14	
Kr-85	1.9E+19		-----	
Kr-85m	5.2E+17	2.5E+10	-----	
Kr-87	9.4E+16	3.0E+09	-----	
Kr-88	2.8E+16	1.7E+10	-----	
Sr-89	3.7E+14		4.4E+16	
Sr-90	1.2E+13		2.2E+15	1.1E+06
Y-90	8.2E+15		4.0E+15	
Y-91	-----		3.1E+15	
Zr-95	1.7E+14		3.7E+13	2.2E+08
Nb-95	1.3E+14		1.1E+14	5.7E+08
Mo-99	5.4E+15		1.3E+16	
Ru-103	1.2E+15		1.8E+14	
Ru-106	7.7E+13		2.7E+14	3.5E+06
Ag-110m	3.8E+13		1.8E+13	4.1E+05
Sb-122	-----		1.8E+14	8.5E+06
Sb-124	2.5E+14		4.8E+13	1.8E+07
Sb-125	-----		1.9E+14	
Te-132	1.4E+15		2.9E+13	
I-123	-----		4.2E+16	

Table 2.02 (continued): Radionuclides Detected in Effluents

Nuclide	Gaseous Effluent DEL (Bq/a)	Release (Bq)	Liquid Effluent DEL (Bq/a)	Release (Bq)
I-125	-----		2.3E+14	
I-129	-----		1.9E+13	
I-131	2.2E+13		3.0E+14	
I-132	1.5E+16		2.4E+16	
I-133	8.9E+14		3.5E+15	
I-134	1.9E+16		3.6E+17	
I-135	7.7E+15		9.2E+15	
Xe-131m	9.9E+18		-----	
Xe-133	2.4E+18	1.5E+12	-----	
Xe-133m	2.8E+18		-----	
Xe-135	3.4E+17	6.2E+11	-----	
Xe-135m	2.0E+17	2.0E+10	-----	
Xe-138	2.2E+16	5.9E+10	-----	
Cs-134	1.9E+13		2.5E+14	
Cs-135	-----		3.4E+15	
Cs-136	-----		6.3E+14	
Cs-137	5.4E+12	8.8E+04	4.0E+14	4.6E+07
Ba-140	7.4E+14		9.4E+15	
La-140	1.1E+16		4.7E+14	
Ce-141	2.1E+15		7.4E+14	
Ce-144	1.1E+14		2.8E+14	4.4E+05
Np-239	1.0E+16		-----	
Noble Gas	7.3E+16 (Bq-MeV)		-----	
Cu-64	-----		-----	4.2E+06
Sn-113	-----		-----	
Xe-137	-----	4.5E+10	-----	
Gd-153	-----		-----	9.7E+06
Tb-160	-----		-----	2.3E+07
Hf-181	-----		-----	
Alpha	-----		-----	1.4E+07
Beta	-----		-----	1.0E+08

Table 2.02: Radionuclides Detected in Effluents

<i>Nuclide</i>	<i>Gaseous Effluent DEL (Bq/a)</i>	<i>Release (Bq)</i>	<i>Liquid Effluent DEL (Bq/a)</i>	<i>Release (Bq)</i>
H-3	4.3E+17	1.3E+14	1.6E+19	9.6E+13
C-14	3.3E+15	2.3E+11	3.0E+14	1.7E+09
Na-24	5.6E+15		-----	
Ar-41	6.4E+16	3.7E+12	-----	
Sc-46	1.7E+14		-----	
Cr-51	2.4E+16		2.2E+15	3.6E+07
Mn-54	1.1E+14		6.4E+13	2.3E+06
Fe-55	-----		5.1E+14	
Fe-59	4.0E+14		3.1E+13	7.4E+06
Co-58	3.0E+14		7.5E+13	
Co-60	6.5E+12	1.1E+06	1.8E+13	2.6E+08
Zn-65	7.1E+13		1.5E+13	
As-76	-----		3.2E+14	
Kr-85	1.9E+19		-----	
Kr-85m	5.2E+17	2.5E+10	-----	
Kr-87	9.4E+16	3.0E+09	-----	
Kr-88	2.8E+16	1.7E+10	-----	
Sr-89	3.7E+14		4.4E+16	
Sr-90	1.2E+13		2.2E+15	1.1E+06
Y-90	8.2E+15		4.0E+15	
Y-91	-----		3.1E+15	
Zr-95	1.7E+14		3.7E+13	2.2E+08
Nb-95	1.3E+14		1.1E+14	5.7E+08
Mo-99	5.4E+15		1.3E+16	
Ru-103	1.2E+15		1.8E+14	
Ru-106	7.7E+13		2.7E+14	3.5E+06
Ag-110m	3.8E+13		1.8E+13	4.1E+05
Sb-122	-----		1.8E+14	8.5E+06
Sb-124	2.5E+14		4.8E+13	1.8E+07
Sb-125	-----		1.9E+14	
Te-132	1.4E+15		2.9E+13	
I-123	-----		4.2E+16	

Table 2.02 (continued): Radionuclides Detected in Effluents

Nuclide	Gaseous Effluent DEL (Bq/a)	Release (Bq)	Liquid Effluent DEL (Bq/a)	Release (Bq)
I-125	-----		2.3E+14	
I-129	-----		1.9E+13	
I-131	2.2E+13		3.0E+14	
I-132	1.5E+16		2.4E+16	
I-133	8.9E+14		3.5E+15	
I-134	1.9E+16		3.6E+17	
I-135	7.7E+15		9.2E+15	
Xe-131m	9.9E+18		-----	
Xe-133	2.4E+18	1.5E+12	-----	
Xe-133m	2.8E+18		-----	
Xe-135	3.4E+17	6.2E+11	-----	
Xe-135m	2.0E+17	2.0E+10	-----	
Xe-138	2.2E+16	5.9E+10	-----	
Cs-134	1.9E+13		2.5E+14	
Cs-135	-----		3.4E+15	
Cs-136	-----		6.3E+14	
Cs-137	5.4E+12	8.8E+04	4.0E+14	4.6E+07
Ba-140	7.4E+14		9.4E+15	
La-140	1.1E+16		4.7E+14	
Ce-141	2.1E+15		7.4E+14	
Ce-144	1.1E+14		2.8E+14	4.4E+05
Np-239	1.0E+16		-----	
Noble Gas	7.3E+16 (Bq-MeV)		-----	
Cu-64	-----		-----	4.2E+06
Sn-113	-----		-----	
Xe-137	-----	4.5E+10	-----	
Gd-153	-----		-----	9.7E+06
Tb-160	-----		-----	2.3E+07
Hf-181	-----		-----	
Alpha	-----		-----	1.4E+07
Beta	-----		-----	1.0E+08

3 Sample Media, Locations and Frequencies

The data contained in this report are for samples collected from January 1 to December 31, 2000, with some overlap for air, precipitation and TLD samples. During this time, the major media analysed and their frequency of collection were as indicated in Table 3.01. Sample collection usually takes place at least once each week throughout the year. The number of each sample type and the major radionuclide measurements performed are listed in Table 3.02.

The miscellaneous samples include those which do not readily fit into any of these listed categories or are not routinely collected. These include numerous in-station samples (e.g. drinking water) relating to the operation of PLGS.

The major sample locations are listed in Table 3.03 (details in Appendix C) and shown in Figures 3.02 to 3.05. Each "Indicator" site has a three or four-character identification code (e.g. F01, I00A). An Indicator site is one within the possible influence of PLGS emissions. "Reference" locations, chosen to lie outside the influence of PLGS emissions, are identified by the letter R at the end of the location code (e.g. A01R).

Sample locations for mobile seafood species (lobster, fish, etc.) caught in the Point Lepreau area are specified as accurately as reasonably possible. The location of capture, however, may bear little relationship to where the animal has been in the recent past. The availability of such samples is not generally predictable and is outside of the control of the laboratory.

Table 3.01: Schedule Of Sample Collection and Analysis

<i>Sample Medium</i>	<i>Typical Frequency</i>
<i>Atmospheric Sampling</i>	
Airborne Particulates	Monthly (integrated sample)
Airborne Iodines	Monthly (integrated sample)
Airborne Water Vapour	Monthly (integrated sample)
Airborne Carbon Dioxide	Monthly (integrated sample)
Ambient Gamma (TLDs)	Quarterly (integrated sample)
Gaseous Effluent Monitor (GEM) Filters	Weekly Composite (integrated sample)
<i>Terrestrial Sampling</i>	
Ambient Gamma (TLDs)	Quarterly (integrated sample)
Milk - commercial dairy	Monthly
- dairy farms	Quarterly
Well Water	Semi-annually
Pond, Puddle and Surface Water	Quarterly
Berries	As Available
Garden Vegetables	As Available
Vegetation	Quarterly
Soil	Quarterly
Precipitation	Monthly (integrated sample)
<i>Marine Sampling</i>	
Seawater	Quarterly
Clams	As Available
Fish	As Available
Lobster	As Available
Periwinkles	As Available
Aquaculture Salmon	As Available
Scallops	As Available
Crabs	As Available
Dulse	As Available
Other Sea Plants	Quarterly
Sediment	Quarterly
Gamma Surveys (Beaches)	Quarterly
Liquid Effluent Monitor (LEM) Composite	Monthly Composite (integrated sample)

Table 3.01 (continued): Schedule Of Sample Collection and Analysis

<i>Sample Medium</i>	<i>Typical Frequency</i>
<i>Solid Radioactive Waste Management Facility</i>	
Bore Holes	Quarterly
Parshall Flumes	Weekly
Ambient Gamma (TLDs)	Quarterly (integrated sample)
<i>Hemlock Knoll Regional Sanitary Landfill</i>	
Soil	Quarterly
Bore Holes	Semi-annually
Water (leachate and settling/holding ponds)	Monthly to Semi-annually
Gamma Surveys	Quarterly
Ambient Gamma (TLDs)	Quarterly (integrated sample)

Table 3.02: Sample Information

<i>Sample Medium</i>	<i>Number of Samples</i>	<i>Radionuclide Measurements</i>
<i>Atmospheric Sampling</i>		
Airborne Particulates	96	gamma emitters & gross alpha/beta
Airborne Iodines	96	I-130,131,132,133,135
Airborne Water Vapour	96	H-3
Airborne Carbon Dioxide	36	C-14
Ambient Gamma (TLDs)*	152*	gamma exposure
GEM Filters	52	Sr-89,90 & gamma emitters
<i>Terrestrial Sampling</i>		
Ambient Gamma (TLDs)*	152*	gamma exposure
Milk - commercial dairy	12	gamma emitters & H-3
- dairy farms	12	
Well Water	24	gamma emitters, gross alpha/beta & H-3
Pond, Puddle and Surface Water	16	gamma emitters & H-3
Berries	6	gamma emitters
Garden Vegetables	32	gamma emitters
Vegetation	16	gamma emitters
Soil	36	gamma emitters
Precipitation	48	gamma emitters & H-3
<i>Marine Sampling</i>		
Seawater	17	gamma emitters & H-3
Clams	9	gamma emitters
Fish	1	gamma emitters
Lobster	6	gamma emitters
Periwinkles	12	gamma emitters
Aquaculture Salmon	2	gamma emitters
Scallops	1	gamma emitters
Crabs	0	gamma emitters
Dulse	8	gamma emitters
Other Sea Plants	14	gamma emitters
Sediment	40	gamma emitters
Gamma Surveys (Beaches)	40	gamma exposure
LEM Composite	12	Sr-89,90, gamma emitters, gross alpha/beta

*One TLD measures the gamma dose from radionuclides in the air and on the ground.

Table 3.02 (continued): Sample Information

<i>Sample Medium</i>	<i>Number of Samples</i>	<i>Radionuclide Measurements</i>
<i>Solid Radioactive Waste Management Facility</i>		
Bore Holes	56	gamma emitters & H-3
Parshall Flumes	106	gamma emitters & H-3
Ambient Gamma (TLDs)	171	gamma exposure
<i>Hemlock Knoll Regional Sanitary Landfill</i>		
Solid	32	gamma emitters
Bore Holes	62	gamma emitters & H-3
Liquid (leachate and settling/holding ponds)	38	gamma emitters & H-3
Gamma Surveys	32	gamma exposure
Ambient Gamma (TLDs)	20	gamma exposure
<i>Other</i>		
Miscellaneous	80	as required
Quality Assurance	348	as required

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Table 3.03: General Location Codes

Code	Location
A	West of Pennfield Ridge
B	Pennfield to New River Beach (inclusive)
C	Lepreau and Lepreau Harbour
D	Little Lepreau and Little Lepreau Basin
E	Maces Bay
F	Welch Cove
G	Pt. Lepreau lighthouse and surrounding area
H	Duck Cove
I	PLGS site – northeast quadrant
J	PLGS site – southeast quadrant
K	PLGS site – southwest quadrant
L	PLGS site – northwest quadrant
M	PLGS
N	Dipper Harbour
P	East of Dipper Harbour East to Musquash
Q	Lorneville
S	Saint John and surrounding area
T	Taymouth
X	Fredericton and surrounding area
Y	Hemlock Knoll Regional Sanitary Landfill

Table 3.03: General Location Codes

<i>Code</i>	<i>Location</i>
A	West of Pennfield Ridge
B	Pennfield to New River Beach (inclusive)
C	Lepreau and Lepreau Harbour
D	Little Lepreau and Little Lepreau Basin
E	Maces Bay
F	Welch Cove
G	Pt. Lepreau lighthouse and surrounding area
H	Duck Cove
I	PLGS site – northeast quadrant
J	PLGS site – southeast quadrant
K	PLGS site – southwest quadrant
L	PLGS site – northwest quadrant
M	PLGS
N	Dipper Harbour
P	East of Dipper Harbour East to Musquash
Q	Lorneville
S	Saint John and surrounding area
T	Taymouth
X	Fredericton and surrounding area
Y	Hemlock Knoll Regional Sanitary Landfill

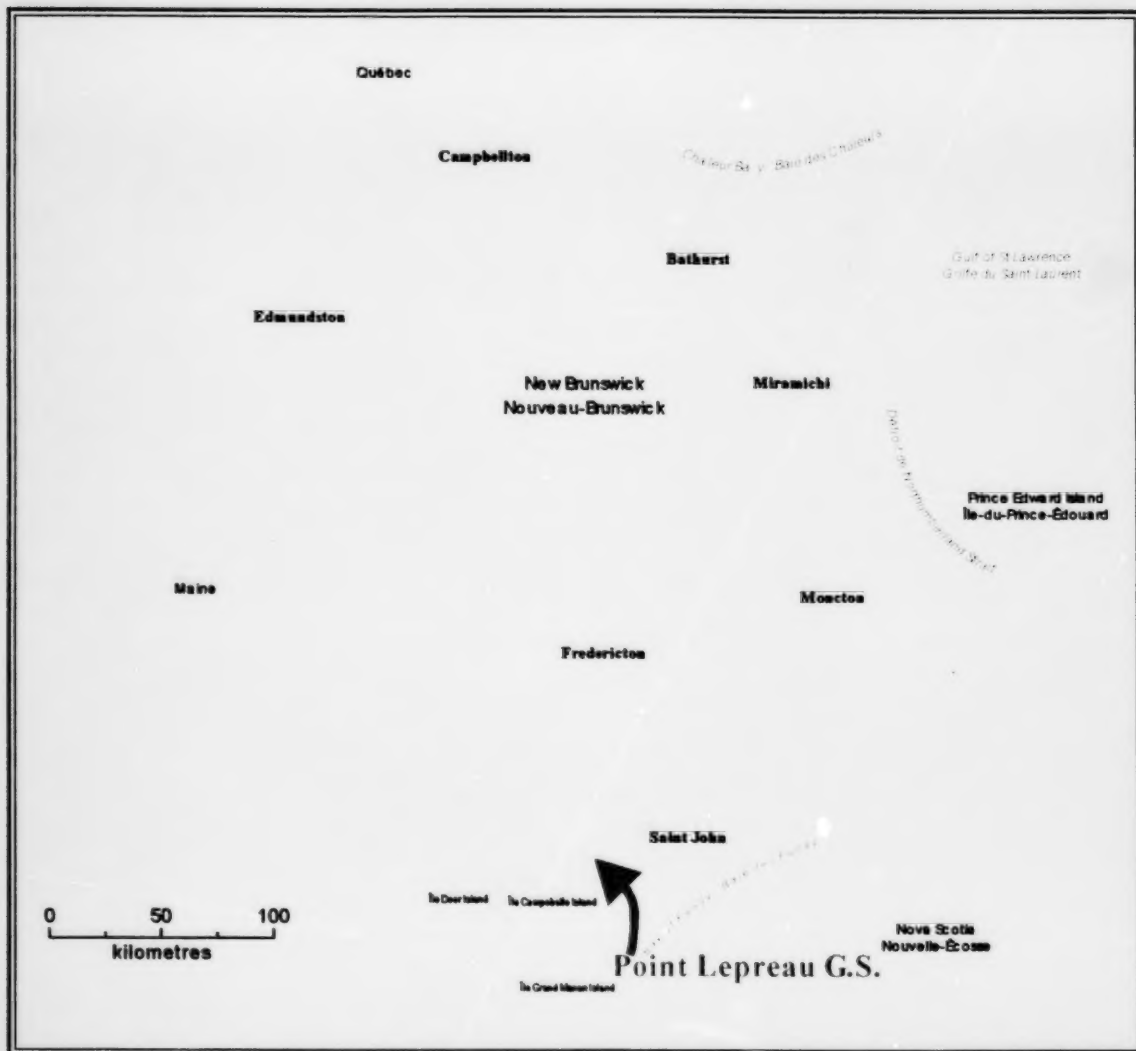


Figure 3.01: Map of Region

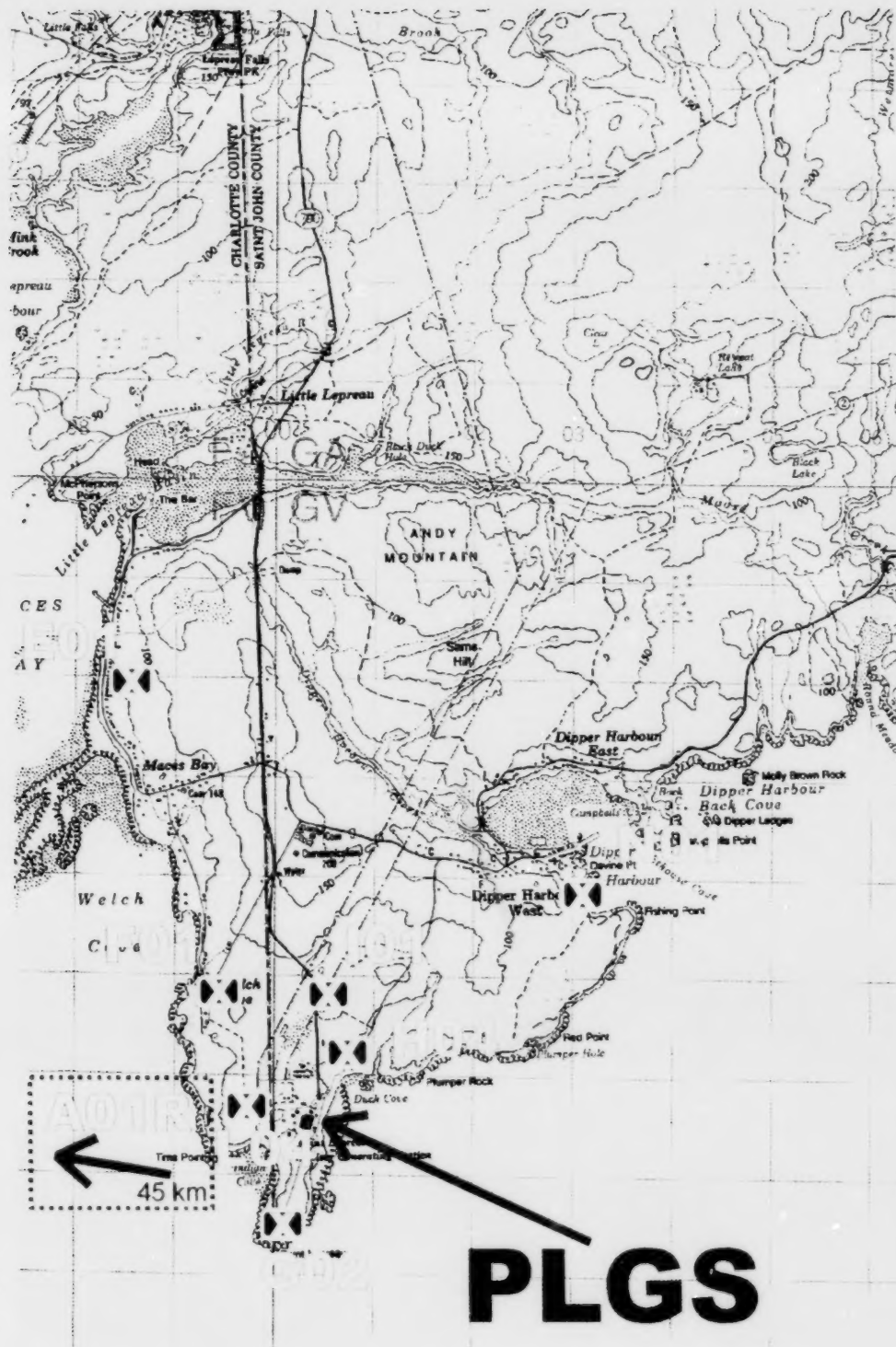


Figure 3.02: Air Monitoring Stations

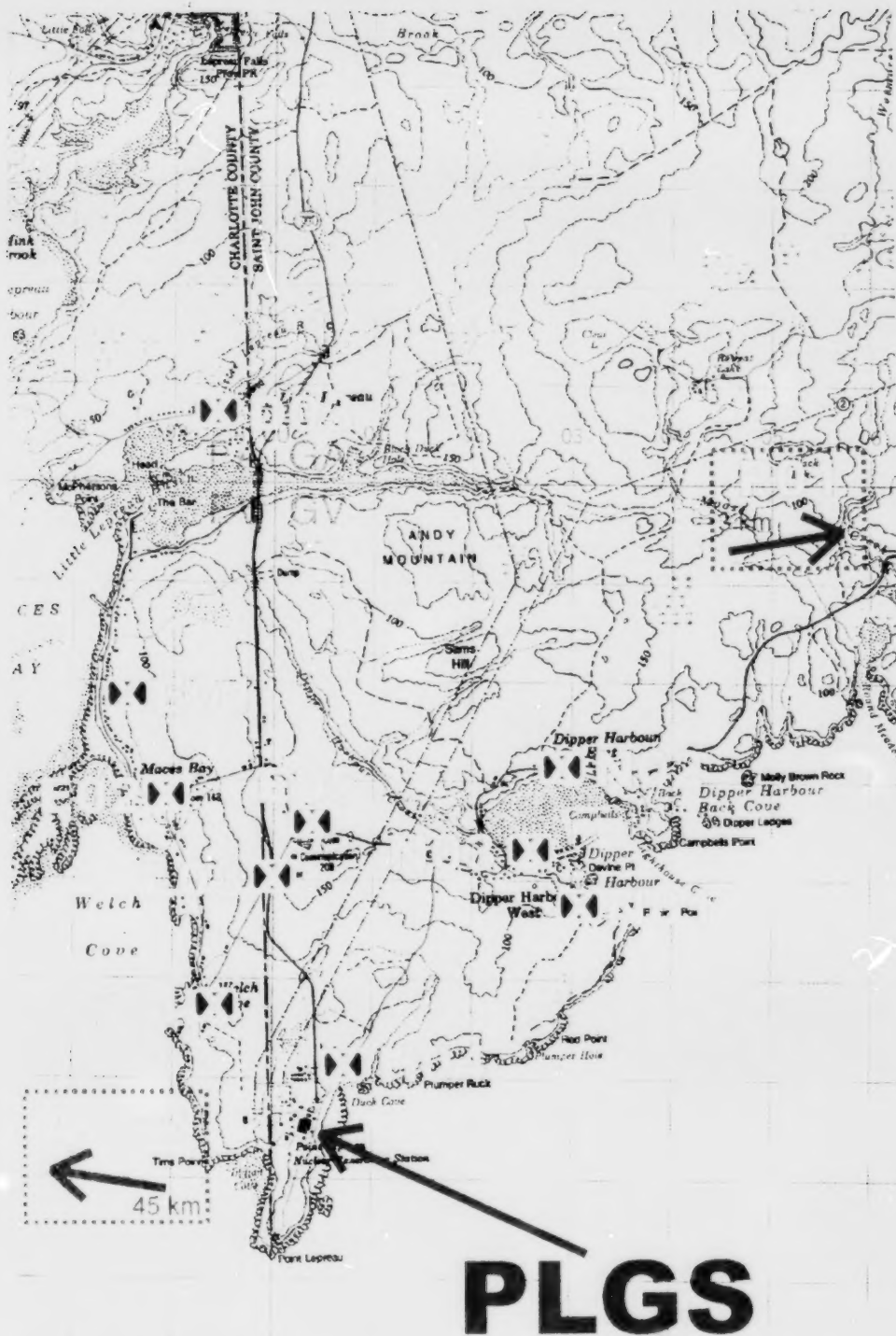


Figure 3.03: Well Water Sites

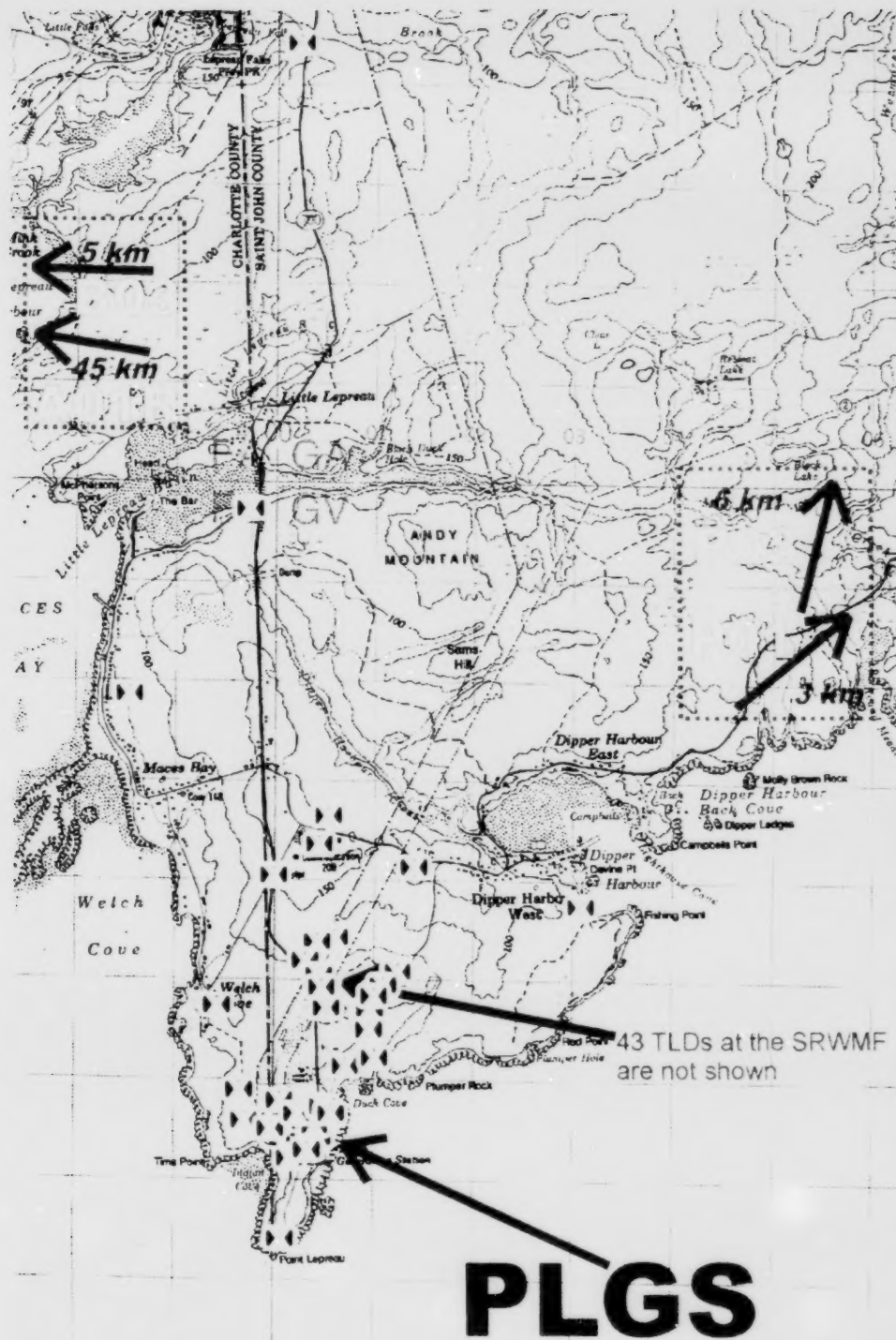


Figure 3.04: TLD Sites

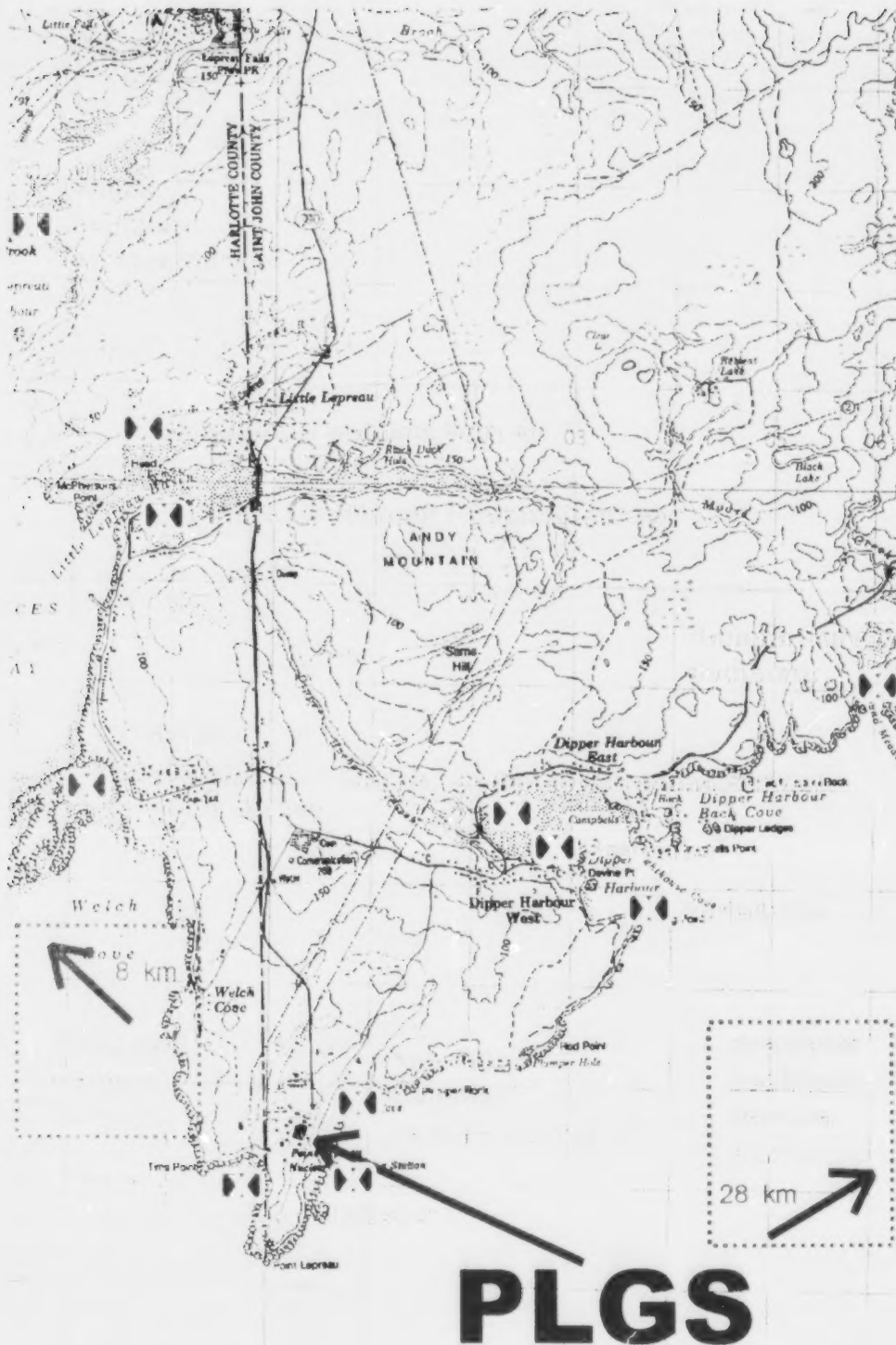


Figure 3.05: Marine Monitoring Sites

4 Summary and Discussion of Data

The following is a summary and discussion of the data on environmental samples collected for the year 2000.

Most samples contained detectable levels of naturally occurring (K-40) or cosmogenic (Be-7) radionuclides. Some contained Cs-137 (soils, sediments, lichen) from the atmospheric bomb tests of past years and the Chernobyl accident. The only radionuclide originating from PLGS that is detected consistently is tritium (in air and fresh water). In 2000, analyses that indicated emissions traceable to PLGS were:

- H-3 in airborne water vapour and fresh water
- gross beta in air at onsite locations
- TLD measurements at onsite locations
- H-3 in Parshall flume and bore hole water from the Solid Radioactive Waste Management Facility (SRWMF)

The only assessable radiation dose from PLGS on the local population is that from tritiated water vapour in air. Outside the 1 km boundary, the activity of H-3 in air ranges from less than about $2\text{E-}2 \text{ Bq/m}^3$ (below the lower limit of detection by the method used) to about 1 Bq/m^3 of air. The natural concentration of H-3 is up to 0.7 Bq/L in most surface waters and up to $1\text{E-}3 \text{ Bq/m}^3$ in air.

The natural concentration of C-14 in the atmosphere is approximately $4\text{E-}2 \text{ Bq/m}^3$. This level is usually detected by the new, extremely sensitive analytical method used in the monitoring program.

Only detected radionuclides are listed in the following tables. Refer to Tables A.01 to A.11 in Appendix A for detailed listings of detection limits. Most tables contain the following data:

Column 1 - Shows the type of analysis or nuclide.

Column 2 - Shows the total number of samples analysed.

Column 3 - Shows the mean of the Critical Levels (CLs) for all samples. Any measurement greater than the CL is considered detected at the 99% confidence level (an explanation of the statistical protocol is given in Appendix A).

Column 4 - Shows the range of the Critical Levels (CLs) for all samples. Any measurement greater than the CL is considered detected at the 99% confidence level (an explanation of the statistical protocol is given in Appendix A).

Column 5 - Shows the mean of the detected values (i.e., values exceeding the CL) for all Indicator stations.

Column 6 - Shows the ratio of the number of detected values to the total number of Indicator samples.

Column 7 - Shows the range of detected values for the Indicator stations.

Column 8 - Shows the mean of detected values at the Reference location(s).

Column 9 - Shows the ratio of detected values to the total number of samples at this location.

Column 10 - Shows the range of detected values for the Reference location(s).

4.01 Airborne Particulates

In 2000, there were no detectable airborne particulate radionuclides that could be attributed to the operation of PLGS on any of the 96 samples analysed. However, the gross beta values were slightly higher at onsite locations than offsite locations.

Air is continuously monitored from the eight locations shown in Figure 3.02. Once a month the filters are changed and analysed. There were only 12 collection days lost (total for three locations) in 2000. It is not uncommon to lose some monitoring time due to mechanical or electrical problems.

Gross alpha and gross beta measurements are an indication of total activity in the environment. This includes naturally occurring (K-40), cosmogenic (Be-7), and man-made sources of radiation. Table 4.01 is a summary of these detected radionuclides. Figures 4.01 and 4.02 show the gross beta results for each location throughout the year. There is a slight seasonal trend as well as a small difference between onsite and offsite results.

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Table 4.01: Airborne Particulates (Bq/m³)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
<i>Alpha</i>	96	2.8E-6	9.4E-7 to 1.0E-5	2.2E-5	84/84	9.3E-6 to 5.9E-5	1.4E-5	12/12	9.0E-6 to 2.7E-5
<i>Beta</i>	96	6.2E-6	2.7E-6 to 1.9E-5	2.5E-4	84/84	9.9E-5 to 5.7E-4	1.8E-4	12/12	1.4E-4 to 2.8E-4
<i>Be-7</i>	96	2.3E-4	3.7E-5 to 1.1E-3	1.5E-3	80/84	5.2E-4 to 3.1E-3	1.0E-3	11/12	5.0E-4 to 1.7E-3
<i>K-40</i>	96	5.2E-4	1.5E-4 to 1.8E-3	4.5E-4	1/84	4.5E-4 to 4.5E-4	*	*	*

*The activity is less than or equal to the Critical Level (99% Confidence Level).

Table 4.01: Airborne Particulates (Bq/m^3)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
<i>Alpha</i>	96	2.8E-6	9.4E-7 to 1.0E-5	2.2E-5	84/84	9.3E-6 to 5.9E-5	1.4E-5	12/12	9.0E-6 to 2.7E-5
<i>Beta</i>	96	6.2E-6	2.7E-6 to 1.9E-5	2.5E-4	84/84	9.9E-5 to 5.7E-4	1.8E-4	12/12	1.4E-4 to 2.8E-4
<i>Be-7</i>	96	2.3E-4	3.7E-5 to 1.1E-3	1.5E-3	80/84	5.2E-4 to 3.1E-3	1.0E-3	11/12	5.0E-4 to 1.7E-3
<i>K-40</i>	96	5.2E-4	1.5E-4 to 1.8E-3	4.5E-4	1/84	4.5E-4 to 4.5E-4	*	*	*

*The activity is less than or equal to the Critical Level (99% Confidence Level).

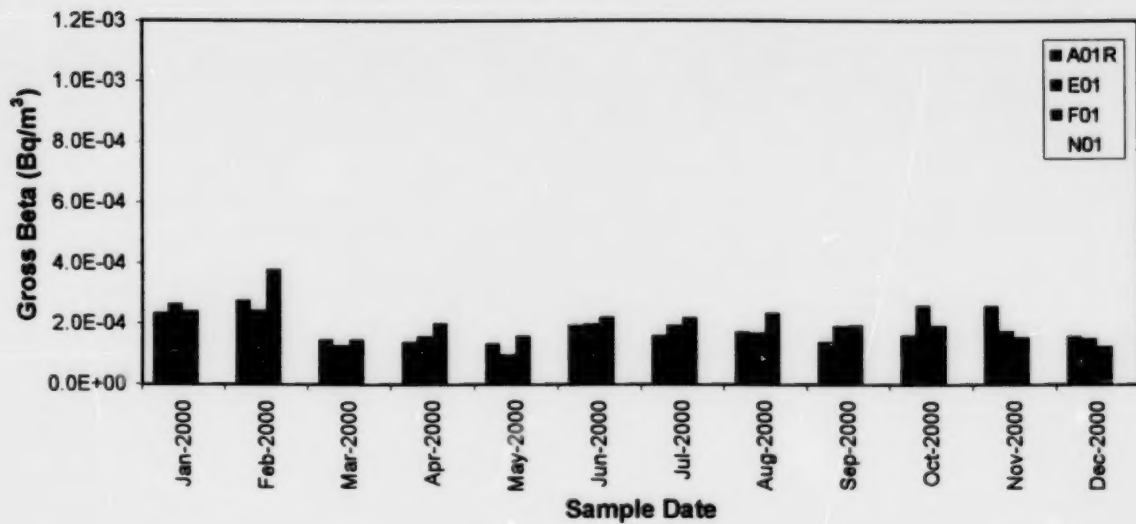


Figure 4.01: Gross Beta in Air for Each Offsite Air Station

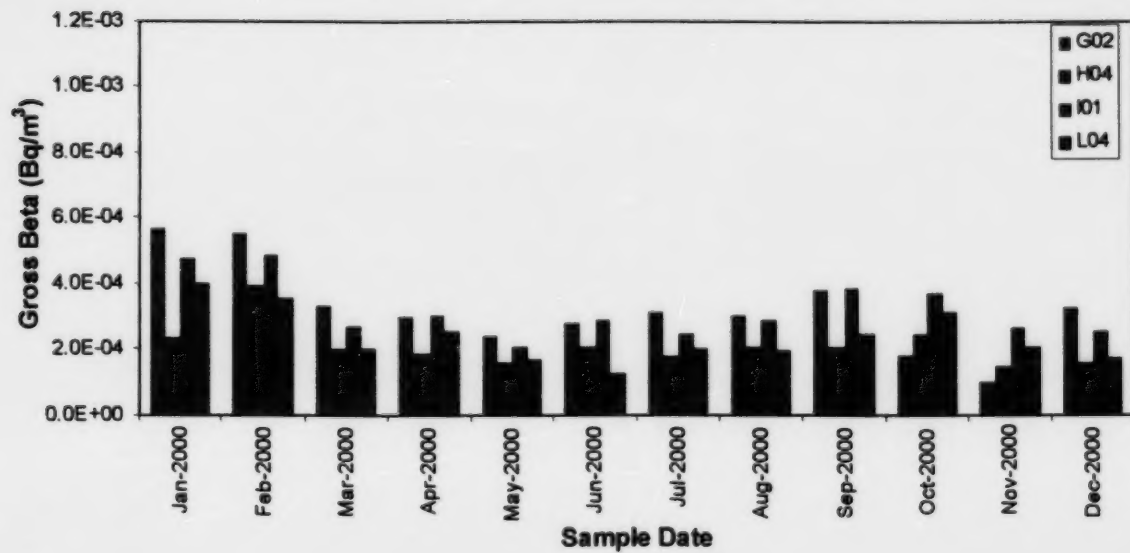


Figure 4.02: Gross Beta in Air for Each Onsite Air Station

4.02 Airborne Iodines

Iodine-131 was consistently below the Critical Level (average $8\text{E-}6 \text{ Bq/m}^3$) on the 96 samples analysed.

Air is monitored continuously from the eight locations shown in Figure 3.02. Once a month the cartridges are changed and analysed. There were only 12 collection days lost (total for three locations) in 2000. It is not uncommon to lose some monitoring time due to mechanical or electrical problems.

The results are consistent with the fact that I-131 was not detected in the emissions from PLGS.

4.03 Water Vapour

Tritium was detected in 72 of the 84 samples collected from the air monitoring stations on the Point Lepreau peninsula in 2000, and was not detected in the 12 samples at the reference location.

Air is monitored continuously from the eight locations shown in Figure 3.02. Once a month the molecular sieve bombs are changed and analysed. There were only 12 collection days lost (total for three locations) in 2000. It is not uncommon to lose some monitoring time due to mechanical or electrical problems.

The maximum concentration of tritium in air on site was 4.3 Bq/m^3 of air. Off site it reached 1.0 Bq/m^3 . Tritium has been detected from time to time at the reference location, even before PLGS became operational.

Table 4.02 is the summary table of 2000 tritium data and Table 4.03 gives details of 2000 tritium results by location (graphically shown in Figures 4.03 and 4.04). Locations to the northeast (H04, I01 and N01) have elevated H-3 measurements in the warmer months due to the predominant summer wind direction which changes in the winter to impact the southwest locations (G02 and L04).

Table 4.02: Water Vapour - Tritium (Bq/m^3)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
H-3	96	5.8E-2	1.3E-2 to 1.2E-1	9.6E-1	72/84	2.1E-2 to 4.3E+0	*	*	*

*The activity is less than or equal to the Critical Level (99% Confidence Level).

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Table 4.03: Water Vapour - Tritium (Bq/m³)

Location Code	A01R	E01	F01	G02	H04	I01	L04	N01
Location	Bocabec	Maces Bay	Welch Cove	Lepreau Lighthouse	Old Site of Information Centre	SRWMF	Construction Stores	Dipper Harbour
Distance from PLGS	45 km	4.5 km	1.6 km	1.0 km	0.75 km	1.2 km	0.55 km	3.7 km
Collection Start Date The sample collection periods are approximately one month in duration. All sample stations are changed at the same time. The start date is the stop date for the previous sample.	2000-01-06	<4.1E-2	2.1E-2	9.1E-2	3.8E-1	8.5E-1	2.8E-1	<4.6E-2
	2000-02-03	<2.9E-2	<2.8E-2	3.8E-2	3.9E-1	1.2E+0	7.0E-1	1.3E-1
	2000-03-02	<3.3E-2	<4.8E-2	1.1E-1	5.9E-1	1.7E+0	3.6E-1	9.6E-2
	2000-04-06	<3.6E-2	<4.9E-2	6.1E-2	4.9E-1	1.8E+0	6.9E-1	1.9E-1
	2000-05-02	<5.2E-2	<6.3E-2	5.3E-2	3.5E-1	1.9E+0	7.2E-1	4.4E-1
	2000-06-06	<6.0E-2	1.0E-1	1.6E-1	2.7E-1	2.6E+0	4.3E-1	5.1E-1
	2000-07-05	<8.2E-2	2.6E-1	4.8E-1	5.4E-1	2.8E+0	9.2E-1	5.0E-1
	2000-08-02	<1.0E-1	2.2E-1	3.2E-1	3.6E-1	2.6E+0	6.3E-1	1.0E+0
	2000-09-07	<1.9E-2	<9.6E-2	1.2E-1	1.5E+0	4.1E+0	7.6E-1	6.4E-1
	2000-10-11	<6.2E-2	<1.4E-1	<7.5E-2	2.6E+0	3.7E+0	5.5E-1	5.3E-1
	2000-11-08	<9.3E-2	<7.3E-2	<6.2E-2	1.6E+0	2.2E+0	6.8E-1	5.6E-2
	2000-12-06	<2.2E-2	<2.5E-2	<6.1E-2	5.0E-1	8.6E-1	5.4E-1	6.5E-2

Table 4.03: Water Vapour - Tritium (Bq/m^3)

Location Code	A01R	E01	F01	G02	H04	I01	L04	N01
Location	Bocabe	Maces Bay	Welch Cove	Lepreau Lighthouse	Old Site of Information Centre	SRWMF	Construction Stores	Dipper Harbour
Distance from PLGS	45 km	4.5 km	1.6 km	1.0 km	0.75 km	1.2 km	0.55 km	3.7 km
2000-01-06	<4.1E-2	2.1E-2	9.1E-2	2.9E-1	3.8E-1	8.5E-1	2.8E-1	<4.6E-2
2000-02-03	<2.9E-2	<2.8E-2	3.8E-2	3.9E-1	9.5E-1	1.2E+0	7.0E-1	1.3E-1
2000-03-02	<3.3E-2	<4.8E-2	1.1E-1	5.9E-1	1.8E+0	1.7E+0	3.6E-1	9.6E-2
2000-04-06	<3.6E-2	<4.9E-2	6.1E-2	4.9E-1	1.6E+0	1.8E+0	6.9E-1	1.9 E-1
2000-05-02	<5.2E-2	<6.3E-2	5.3E-2	3.5E-1	2.1E+0	1.9E+0	7.2E-1	4.4E-1
2000-06-06	<6.0E-2	1.0E-1	1.6E-1	2.7E-1	1.5E+0	2.6 E+0	4.3E-1	5.1E-1
2000-07-05	<8.2E-2	2.6E-1	4.8E-1	5.4E-1	2.9E+0	2.8E+0	9.2E-1	5.0E-1
2000-08-02	<1.0E-1	2.2E-1	3.2E-1	3.6E-1	2.4E+0	2.6E+0	6.3E-1	1.0E+0
2000-09-07	<1.9E-2	<9.6E-2	1.2E-1	1.5E+0	4.3E+0	4.1E+0	7.6E-1	6.4E-1
2000-10-11	<6.2E-2	<1.4E-1	<7.5E-2	2.6E+0	1.5E+0	3.7E+0	5.5E-1	5.3E-1
2000-11-08	<9.3E-2	<7.3E-2	<6.2 E-2	1.6E+0	7.0E-1	2.2 E+0	6.8E-1	5.6E-2
2000-12-06	<2.2E-2	<2.5E-2	<6.1E-2	5.0E-1	3.0E-1	8.6E-1	5.4E-1	6.5E-2

Collection**Start Date**

The sample collection periods are approximately one month in duration. All sample stations are changed at the same time. The start date is the stop date for the previous sample.

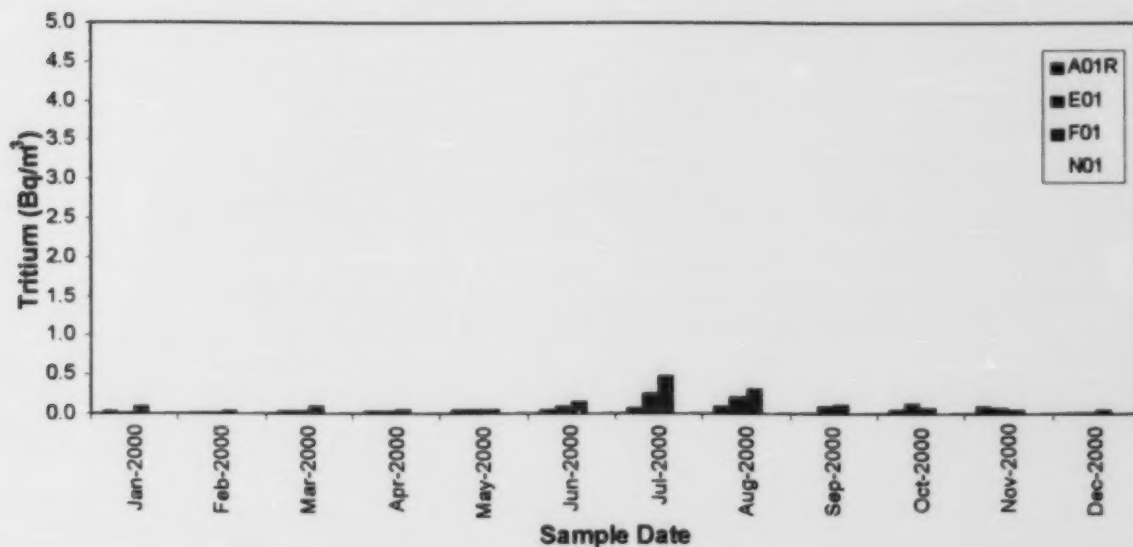


Figure 4.03: Water Vapour (Tritium) for Each Offsite Air Station

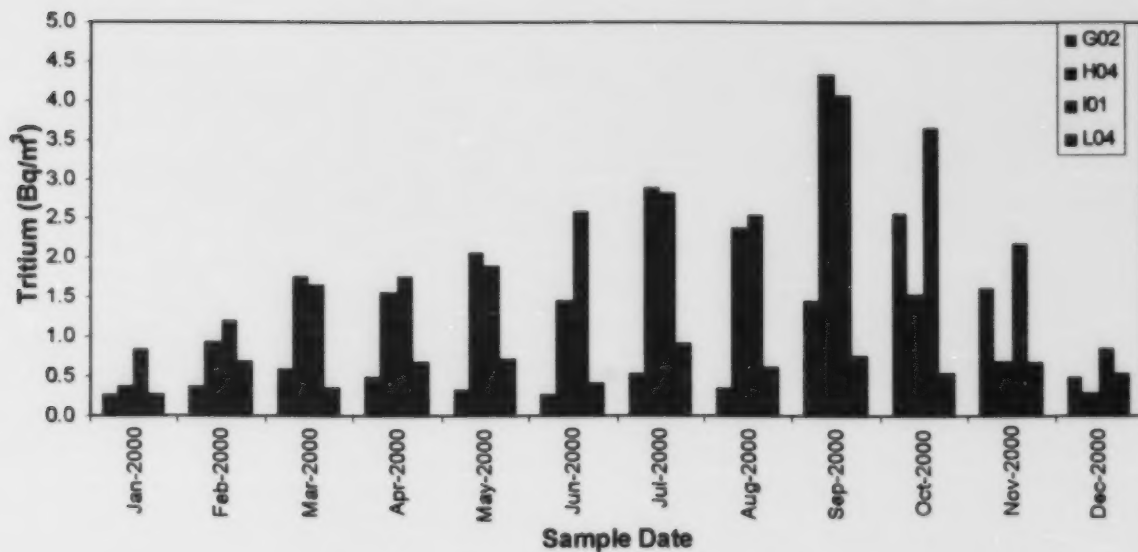


Figure 4.04: Water Vapour (Tritium) for Each Onsite Air Station

4.04 Carbon Dioxide

Carbon-14 was detected in 22 of the 24 samples from the onsite monitors and 10 of the 12 samples from the offsite monitor.

Air is monitored continuously at two onsite locations (G02 and H04 in Figure 3.02) and one reference location. The caustic bubblers are changed monthly and returned to the lab for analysis.

Individual analysis results for 2000 are given in Table 4.04. Based on stack emissions, the calculated average annual concentration of C-14 in air at the boundary fence for 2000 was approximately $8\text{E-}4 \text{ Bq/m}^3$ (well below the natural level of $4\text{E-}2 \text{ Bq/m}^3$). The results for the two onsite monitors (mean of $4.7\text{E-}2 \text{ Bq/m}^3$) were very similar to the reference monitor (mean of $4.4\text{E-}2 \text{ Bq/m}^3$). There was a dramatic improvement in detection limits from previous years due to a more sensitive analytical method being introduced in 2000. This decreased the LLD by a factor of ten.

Table 4.04 is the summary table of 2000 C-14 data and Table 4.05 gives details of 2000 C-14 results by location (graphically shown in Figure 4.05).

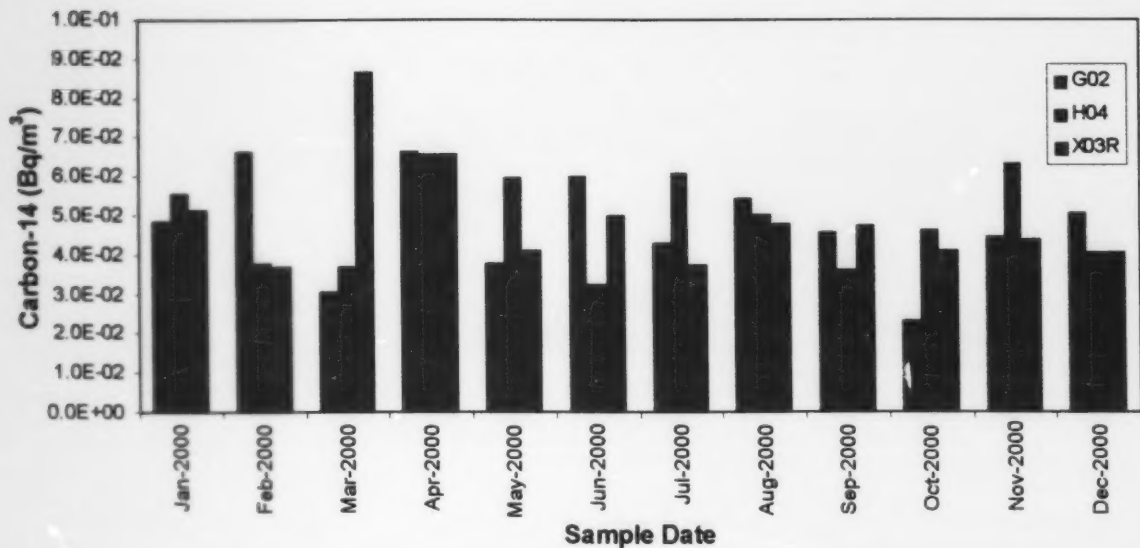


Figure 4.05: Carbon Dioxide (Carbon-14) Bq/m^3

Table 4.04: Carbon Dioxide - Carbon-14 (Bq/m^3)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
C-14	36	2.8E-2	1.9E-2 to 5.0E-2	4.7E-2	22/24	2.3E-2 to 6.6E-2	4.4E-2	10/12	3.7E-2 to 5.2E-2

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Table 4.05: Carbon Dioxide - Carbon-14 (Bq/m^3)

Location Code	G02	H04	X03R
Location	Lepreau Lighthouse	Old Site of Information Centre	Fredericton Laboratory
Distance from PLGS	1.0 km	0.75 km	100 km
2000-01-06	4.9E-2	5.6E-2	5.2E-2
2000-02-03	<6.7E-2	3.8E-2	3.7E-2
2000-03-02	3.1E-2	3.7E-2	<8.7E-2
2000-04-06	<6.7E-2	6.6E-2	<6.6E-2
2000-05-02	3.8E-2	6.0E-2	4.1E-2
2000-06-06	6.0E-2	3.3E-2	5.0E-2
2000-07-05	4.3E-2	6.1E-2	3.8E-2
2000-08-02	5.5E-2	5.0E-2	4.8E-2
2000-09-07	4.6E-2	3.6E-2	4.7E-2
2000-10-11	2.3E-2	4.7E-2	4.1E-2
2000-11-08	4.5E-2	6.3E-2	4.4E-2
2000-12-06	5.1E-2	4.1E-2	4.1E-2

Collection Start Date

The sample collection periods are approximately one month in duration. All sample stations are changed at the same time. The start date is the stop date for the previous sample.

1

Table 4.05: Carbon Dioxide - Carbon-14 (Bq/m^3)

Location Code	G02	H04	X03R
Location	Lepreau Lighthouse	Old Site of Information Centre	Fredericton Laboratory
Distance from PLGS	1.0 km	0.75 km	100 km
Collection Start Date The sample collection periods are approximately one month in duration. All sample stations are changed at the same time. The start date is the stop date for the previous sample.	2000-01-06	4.9E-2	5.2E-2
	2000-02-03	<6.7E-2	3.7E-2
	2000-03-02	3.1E-2	<8.7E-2
	2000-04-06	<6.7E-2	<6.6E-2
	2000-05-02	3.8E-2	4.1E-2
	2000-06-06	6.0E-2	5.0E-2
	2000-07-05	4.3E-2	3.8E-2
	2000-08-02	5.5E-2	4.8E-2
	2000-09-07	4.6E-2	4.7E-2
	2000-10-11	2.3E-2	4.1E-2
	2000-11-08	4.5E-2	4.4E-2
	2000-12-06	5.1E-2	4.1E-2

As part of a CANDU Owners Group sponsored initiative, a system was developed by the AECL for passive sampling of $^{14}\text{CO}_2$ in air using a solid state absorbent.⁽¹³⁾ In 1998, six of the passive sampler systems were deployed in and around PLGS. The samplers contained a caustic chemical which absorbed $^{14}\text{CO}_2$ from the atmosphere. The absorbed $^{14}\text{CO}_2$ could be regenerated after three months in the field and analysed for C-14 content. In 1999, an additional four samplers were deployed around the SRWMF and two more were deployed in a direct line from the stack. These were analysed by AECL for a period of eighteen months. In March 2000, the methodology for the analysis of ^{14}C was transferred to NB Power. All analyses for $^{14}\text{CO}_2$ in air from the passive samplers have since been conducted in-house. Results of ^{14}C content in air generated by the AECL and those generated in-house were directly comparable and did not differ significantly from background levels. The program was suspended at the end of 2000 but may be resumed again in the future.

4.05 Ambient Gamma (TLD)

Gamma exposure measurements were slightly higher onsite, especially near the SRWMF and reactor building, than they were offsite.

Ambient gamma radiation is measured by thermoluminescent dosimeters (TLDs) at the 82 locations shown in Figure 3.04 plus five locations at the Hemlock Knoll Regional Sanitary Landfill (locations YTL1 to YTL5). Forty three of these are near the Solid Radioactive Waste Management Facility. Locations I00A - I00L are on the perimeter fence of the SRWMF-Phase 1, and locations I03A - I03L are on the perimeter of the SRWMF-Phase 2. The Drop Off TLDs for SRWMF-Phase 2 are shown in Table 4.30. TLDs are changed quarterly. All but five of the 348 dosimeters placed in the environment were recovered.

Data for 2000 are given in Table 4.06. The data in the "Total" column are rounded to the nearest ten microgray. If a quarterly measurement is not available (lost or vandalised TLD, animal damage, moisture penetration, etc.) a mean value is calculated from the available measurements in order to provide an estimate for the annual total. The statistical uncertainty shown in the Total column is the square root of the sum of the squares of the uncertainties of the individual quarterly measurements.

The variation in natural background radiation at any individual location covers a range of about 300 microgray from year to year. The locations (J70 and M02) close to the reactor building and the air emissions stack show increases in gamma radiation due to chronic releases of low levels of noble gases. Increases at the SRWMF locations are due to low-level waste and used fuel emplacement, and not to station emissions. There is a small, but undefinable, component of radiation on the TLDs at the SRWMF that is due to enhanced natural radiation from the aggregate in the concrete structures.

Figure 4.06 compares the reference location results with the results for other locations.

The range of values for the 12 TLD locations at the SRWMF - Phase 2 was from 720 to 1470 microgray per annum. The average for the facility is 890 microgray per annum - not significantly different from other low background (and natural) radiation measurements anywhere in Canada.

Table 4.06: Ambient Gamma – TLD (μGy)

Location	Dose ($\mu\text{Gy} \pm 10\%$)				
	1 st Quarter	2 nd Quarter	3 rd Quarter	4 th Quarter	Year
A01R	120 $\pm$ 12	162 $\pm$ 16	162 $\pm$ 16	157 $\pm$ 16	600 $\pm$ 30
B03	135 $\pm$ 14	158 $\pm$ 16	177 $\pm$ 18	152 $\pm$ 15	620 $\pm$ 30
C03	120 $\pm$ 12	147 $\pm$ 15	160 $\pm$ 16	149 $\pm$ 15	580 $\pm$ 30
D02	157 $\pm$ 16	178 $\pm$ 18	200 $\pm$ 20	179 $\pm$ 18	710 $\pm$ 40
E01	151 $\pm$ 15	152 $\pm$ 15	168 $\pm$ 17	147 $\pm$ 15	620 $\pm$ 30
E04	89 $\pm$ 9	97 $\pm$ 10	120 $\pm$ 12	112 $\pm$ 11	420 $\pm$ 20
E05	142 $\pm$ 14	149 $\pm$ 15	165 $\pm$ 17	164 $\pm$ 16	620 $\pm$ 30
E06	212 $\pm$ 21	187 $\pm$ 19	208 $\pm$ 21	196 $\pm$ 20	800 $\pm$ 40
F01	NA	134 $\pm$ 13	135 $\pm$ 14	121 $\pm$ 12	520 $\pm$ 20
G02	174 $\pm$ 17	176 $\pm$ 18	191 $\pm$ 19	184 $\pm$ 18	720 $\pm$ 40
H04	141 $\pm$ 14	155 $\pm$ 16	151 $\pm$ 15	159 $\pm$ 16	610 $\pm$ 30
H05	115 $\pm$ 11	116 $\pm$ 12	139 $\pm$ 14	136 $\pm$ 14	510 $\pm$ 30
I00A	200 $\pm$ 20	216 $\pm$ 22	221 $\pm$ 22	235 $\pm$ 24	870 $\pm$ 40
I00B	220 $\pm$ 22	231 $\pm$ 23	251 $\pm$ 25	247 $\pm$ 25	950 $\pm$ 50
I00C	220 $\pm$ 22	225 $\pm$ 22	219 $\pm$ 22	235 $\pm$ 24	900 $\pm$ 40
I00D	192 $\pm$ 19	210 $\pm$ 21	223 $\pm$ 22	216 $\pm$ 22	840 $\pm$ 40
I00E	204 $\pm$ 20	221 $\pm$ 22	219 $\pm$ 22	232 $\pm$ 23	880 $\pm$ 40
I00F	165 $\pm$ 17	220 $\pm$ 22	231 $\pm$ 23	226 $\pm$ 23	840 $\pm$ 40
I00G	209 $\pm$ 21	219 $\pm$ 22	228 $\pm$ 23	235 $\pm$ 24	890 $\pm$ 40
I00H	218 $\pm$ 22	237 $\pm$ 24	226 $\pm$ 23	241 $\pm$ 24	920 $\pm$ 50
I00I	216 $\pm$ 22	219 $\pm$ 22	247 $\pm$ 25	219 $\pm$ 22	900 $\pm$ 50
I00J	219 $\pm$ 22	226 $\pm$ 23	233 $\pm$ 23	225 $\pm$ 22	900 $\pm$ 50
I00K	218 $\pm$ 22	216 $\pm$ 22	226 $\pm$ 23	220 $\pm$ 22	880 $\pm$ 40
I00L	196 $\pm$ 20	203 $\pm$ 20	216 $\pm$ 22	233 $\pm$ 23	850 $\pm$ 40
I03A	192 $\pm$ 19	207 $\pm$ 21	202 $\pm$ 20	204 $\pm$ 20	810 $\pm$ 40
I03B	186 $\pm$ 19	198 $\pm$ 20	181 $\pm$ 18	182 $\pm$ 18	750 $\pm$ 40
I03C	183 $\pm$ 18	197 $\pm$ 20	201 $\pm$ 20	198 $\pm$ 20	780 $\pm$ 40
I03D	339 $\pm$ 34	370 $\pm$ 37	360 $\pm$ 36	400 $\pm$ 40	1470 $\pm$ 70
I03E	328 $\pm$ 33	353 $\pm$ 35	322 $\pm$ 32	339 $\pm$ 34	1340 $\pm$ 70
I03F	227 $\pm$ 23	205 $\pm$ 21	204 $\pm$ 20	212 $\pm$ 21	850 $\pm$ 40
I03G	168 $\pm$ 17	177 $\pm$ 18	187 $\pm$ 19	193 $\pm$ 19	720 $\pm$ 40
I03H	188 $\pm$ 19	215 $\pm$ 21	201 $\pm$ 20	NA	810 $\pm$ 30
I03I	182 $\pm$ 18	200 $\pm$ 20	192 $\pm$ 19	186 $\pm$ 19	760 $\pm$ 40
I03J	194 $\pm$ 19	209 $\pm$ 21	209 $\pm$ 21	211 $\pm$ 21	820 $\pm$ 40
I03K	192 $\pm$ 19	212 $\pm$ 21	200 $\pm$ 20	205 $\pm$ 20	810 $\pm$ 40
I03L	175 $\pm$ 18	192 $\pm$ 19	187 $\pm$ 19	177 $\pm$ 18	730 $\pm$ 40



Table 4.06: Ambient Gamma – TLD (μGy)

Location	Dose ($\mu\text{Gy} \pm 10\%$)				
	1 st Quarter	2 nd Quarter	3 rd Quarter	4 th Quarter	Year
A01R	120 $\pm$ 12	162 $\pm$ 16	162 $\pm$ 16	157 $\pm$ 16	600 $\pm$ 30
B03	135 $\pm$ 14	158 $\pm$ 16	177 $\pm$ 18	152 $\pm$ 15	620 $\pm$ 30
C03	120 $\pm$ 12	147 $\pm$ 15	160 $\pm$ 16	149 $\pm$ 15	580 $\pm$ 30
D02	157 $\pm$ 16	178 $\pm$ 18	200 $\pm$ 20	179 $\pm$ 18	710 $\pm$ 40
E01	151 $\pm$ 15	152 $\pm$ 15	168 $\pm$ 17	147 $\pm$ 15	620 $\pm$ 30
E04	89 $\pm$ 9	97 $\pm$ 10	120 $\pm$ 12	112 $\pm$ 11	420 $\pm$ 20
E05	142 $\pm$ 14	149 $\pm$ 15	165 $\pm$ 17	164 $\pm$ 16	620 $\pm$ 30
E06	212 $\pm$ 21	187 $\pm$ 19	208 $\pm$ 21	196 $\pm$ 20	800 $\pm$ 40
F01	NA	134 $\pm$ 13	135 $\pm$ 14	121 $\pm$ 12	520 $\pm$ 20
G02	174 $\pm$ 17	176 $\pm$ 18	191 $\pm$ 19	184 $\pm$ 18	720 $\pm$ 40
H04	141 $\pm$ 14	155 $\pm$ 16	151 $\pm$ 15	159 $\pm$ 16	610 $\pm$ 30
H05	115 $\pm$ 11	116 $\pm$ 12	139 $\pm$ 14	136 $\pm$ 14	510 $\pm$ 30
I00A	200 $\pm$ 20	216 $\pm$ 22	221 $\pm$ 22	235 $\pm$ 24	870 $\pm$ 40
I00B	220 $\pm$ 22	231 $\pm$ 23	251 $\pm$ 25	247 $\pm$ 25	950 $\pm$ 50
I00C	220 $\pm$ 22	225 $\pm$ 22	219 $\pm$ 22	235 $\pm$ 24	900 $\pm$ 40
I00D	192 $\pm$ 19	210 $\pm$ 21	223 $\pm$ 22	216 $\pm$ 22	840 $\pm$ 40
I00E	204 $\pm$ 20	221 $\pm$ 22	219 $\pm$ 22	232 $\pm$ 23	880 $\pm$ 40
I00F	165 $\pm$ 17	220 $\pm$ 22	231 $\pm$ 23	226 $\pm$ 23	840 $\pm$ 40
I00G	209 $\pm$ 21	219 $\pm$ 22	228 $\pm$ 23	235 $\pm$ 24	890 $\pm$ 40
I00H	218 $\pm$ 22	237 $\pm$ 24	226 $\pm$ 23	241 $\pm$ 24	920 $\pm$ 50
I00I	216 $\pm$ 22	219 $\pm$ 22	247 $\pm$ 25	219 $\pm$ 22	900 $\pm$ 50
I00J	219 $\pm$ 22	226 $\pm$ 23	233 $\pm$ 23	225 $\pm$ 22	900 $\pm$ 50
I00K	218 $\pm$ 22	216 $\pm$ 22	226 $\pm$ 23	220 $\pm$ 22	880 $\pm$ 40
I00L	196 $\pm$ 20	203 $\pm$ 20	216 $\pm$ 22	233 $\pm$ 23	850 $\pm$ 40
I03A	192 $\pm$ 19	207 $\pm$ 21	202 $\pm$ 20	204 $\pm$ 20	810 $\pm$ 40
I03B	186 $\pm$ 19	198 $\pm$ 20	181 $\pm$ 18	182 $\pm$ 18	750 $\pm$ 40
I03C	183 $\pm$ 18	197 $\pm$ 20	201 $\pm$ 20	198 $\pm$ 20	780 $\pm$ 40
I03D	339 $\pm$ 34	370 $\pm$ 37	360 $\pm$ 36	400 $\pm$ 40	1470 $\pm$ 70
I03E	328 $\pm$ 33	353 $\pm$ 35	322 $\pm$ 32	339 $\pm$ 34	1340 $\pm$ 70
I03F	227 $\pm$ 23	205 $\pm$ 21	204 $\pm$ 20	212 $\pm$ 21	850 $\pm$ 40
I03G	168 $\pm$ 17	177 $\pm$ 18	187 $\pm$ 19	193 $\pm$ 19	720 $\pm$ 40
I03H	188 $\pm$ 19	215 $\pm$ 21	201 $\pm$ 20	NA	810 $\pm$ 30
I03I	182 $\pm$ 18	200 $\pm$ 20	192 $\pm$ 19	186 $\pm$ 19	760 $\pm$ 40
I03J	194 $\pm$ 19	209 $\pm$ 21	209 $\pm$ 21	211 $\pm$ 21	820 $\pm$ 40
I03K	192 $\pm$ 19	212 $\pm$ 21	200 $\pm$ 20	205 $\pm$ 20	810 $\pm$ 40
I03L	175 $\pm$ 18	192 $\pm$ 19	187 $\pm$ 19	177 $\pm$ 18	730 $\pm$ 40

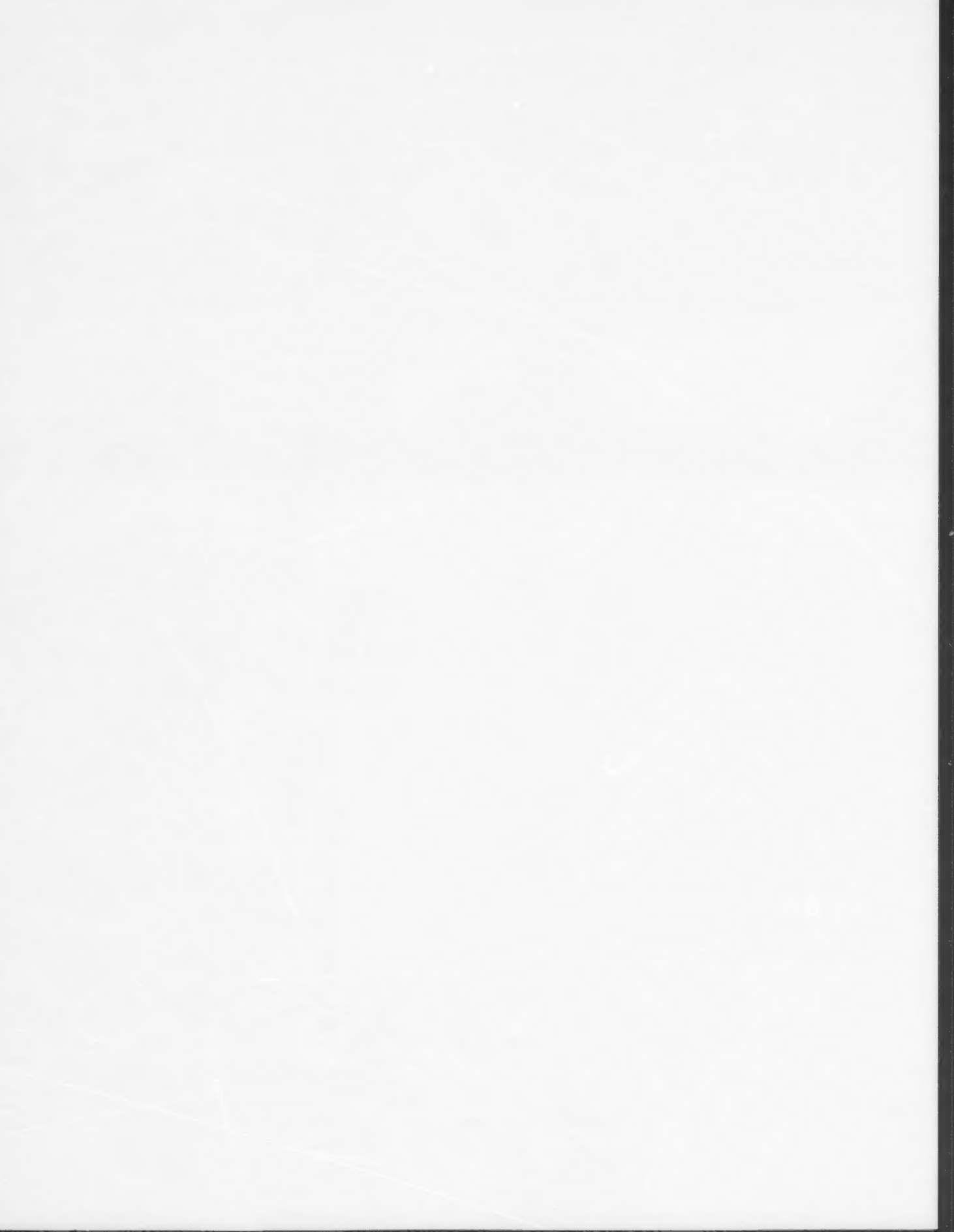


Table 4.06 (continued): Ambient Gamma – TLD (μGy)

Location	Dose ($\mu\text{Gy} \pm 10\%$)				
	1 st Quarter	2 nd Quarter	3 rd Quarter	4 th Quarter	Year
I75	199 $\pm$ 20	197 $\pm$ 20	185 $\pm$ 18	202 $\pm$ 20	780 $\pm$ 40
I86	137 $\pm$ 14	163 $\pm$ 16	159 $\pm$ 16	NA	610 $\pm$ 30
I87	145 $\pm$ 15	172 $\pm$ 17	165 $\pm$ 16	168 $\pm$ 17	650 $\pm$ 30
I88	157 $\pm$ 16	183 $\pm$ 18	168 $\pm$ 17	175 $\pm$ 17	680 $\pm$ 30
I89	152 $\pm$ 15	180 $\pm$ 18	179 $\pm$ 18	165 $\pm$ 16	680 $\pm$ 30
I90	126 $\pm$ 13	132 $\pm$ 13	146 $\pm$ 15	137 $\pm$ 14	540 $\pm$ 30
I91	147 $\pm$ 15	152 $\pm$ 15	172 $\pm$ 17	170 $\pm$ 17	640 $\pm$ 30
I92	138 $\pm$ 14	143 $\pm$ 14	161 $\pm$ 16	163 $\pm$ 16	600 $\pm$ 30
I93	140 $\pm$ 14	142 $\pm$ 14	166 $\pm$ 17	151 $\pm$ 15	600 $\pm$ 30
I94	175 $\pm$ 17	173 $\pm$ 17	187 $\pm$ 19	181 $\pm$ 18	720 $\pm$ 40
I95	133 $\pm$ 13	133 $\pm$ 13	157 $\pm$ 16	148 $\pm$ 15	570 $\pm$ 30
I98	144 $\pm$ 14	156 $\pm$ 16	174 $\pm$ 17	138 $\pm$ 14	610 $\pm$ 30
I99	168 $\pm$ 17	199 $\pm$ 20	202 $\pm$ 20	188 $\pm$ 19	760 $\pm$ 40
J00	156 $\pm$ 16	184 $\pm$ 18	181 $\pm$ 18	177 $\pm$ 18	700 $\pm$ 30
J20	172 $\pm$ 17	181 $\pm$ 18	182 $\pm$ 18	193 $\pm$ 19	730 $\pm$ 40
J35	174 $\pm$ 17	192 $\pm$ 19	188 $\pm$ 19	179 $\pm$ 18	730 $\pm$ 40
J70	310 $\pm$ 31	318 $\pm$ 32	268 $\pm$ 27	NA	1190 $\pm$ 50
K01	186 $\pm$ 19	183 $\pm$ 18	192 $\pm$ 19	197 $\pm$ 20	760 $\pm$ 40
K02	165 $\pm$ 17	198 $\pm$ 20	203 $\pm$ 20	NA	750 $\pm$ 30
L01	141 $\pm$ 14	167 $\pm$ 17	180 $\pm$ 18	153 $\pm$ 15	640 $\pm$ 30
L02	213 $\pm$ 21	205 $\pm$ 21	230 $\pm$ 23	223 $\pm$ 22	870 $\pm$ 40
L03	141 $\pm$ 14	136 $\pm$ 14	143 $\pm$ 14	133 $\pm$ 13	550 $\pm$ 30
L04	178 $\pm$ 18	175 $\pm$ 17	197 $\pm$ 20	186 $\pm$ 19	740 $\pm$ 40
M02	237 $\pm$ 24	261 $\pm$ 26	261 $\pm$ 26	263 $\pm$ 26	1020 $\pm$ 50
N01	150 $\pm$ 15	144 $\pm$ 14	161 $\pm$ 16	153 $\pm$ 15	610 $\pm$ 30
P01	92 $\pm$ 9	112 $\pm$ 11	113 $\pm$ 11	113 $\pm$ 11	430 $\pm$ 20
P03	117 $\pm$ 12	139 $\pm$ 14	150 $\pm$ 15	139 $\pm$ 14	540 $\pm$ 30
YTL1	127 $\pm$ 13	145 $\pm$ 15	142 $\pm$ 14	127 $\pm$ 13	540 $\pm$ 30
YTL2	113 $\pm$ 11	150 $\pm$ 15	151 $\pm$ 15	134 $\pm$ 13	550 $\pm$ 30
YTL3	97 $\pm$ 10	132 $\pm$ 13	121 $\pm$ 12	110 $\pm$ 11	460 $\pm$ 20
YTL4	101 $\pm$ 10	129 $\pm$ 13	112 $\pm$ 11	103 $\pm$ 10	440 $\pm$ 20
YTL5	154 $\pm$ 15	188 $\pm$ 19	189 $\pm$ 19	166 $\pm$ 17	700 $\pm$ 30

NA :Data Not Available - Lost or destroyed TLD for this collection interval.

Table 4.06 (continued): Ambient Gamma – TLD (μGy)

Location	Dose ($\mu\text{Gy} \pm 10\%$)				Year
	1 st Quarter	2 nd Quarter	3 rd Quarter	4 th Quarter	
I75	199 $\pm$ 20	197 $\pm$ 20	185 $\pm$ 18	202 $\pm$ 20	780 $\pm$ 40
I86	137 $\pm$ 14	163 $\pm$ 16	159 $\pm$ 16	NA	610 $\pm$ 30
I87	145 $\pm$ 15	172 $\pm$ 17	165 $\pm$ 16	168 $\pm$ 17	650 $\pm$ 30
I88	157 $\pm$ 16	183 $\pm$ 18	168 $\pm$ 17	175 $\pm$ 17	680 $\pm$ 30
I89	152 $\pm$ 15	180 $\pm$ 18	179 $\pm$ 18	165 $\pm$ 16	680 $\pm$ 30
I90	126 $\pm$ 13	132 $\pm$ 13	146 $\pm$ 15	137 $\pm$ 14	540 $\pm$ 30
I91	147 $\pm$ 15	152 $\pm$ 15	172 $\pm$ 17	170 $\pm$ 17	640 $\pm$ 30
I92	138 $\pm$ 14	143 $\pm$ 14	161 $\pm$ 16	163 $\pm$ 16	600 $\pm$ 30
I93	140 $\pm$ 14	142 $\pm$ 14	166 $\pm$ 17	151 $\pm$ 15	600 $\pm$ 30
I94	175 $\pm$ 17	173 $\pm$ 17	187 $\pm$ 19	181 $\pm$ 18	720 $\pm$ 40
I95	133 $\pm$ 13	133 $\pm$ 13	157 $\pm$ 16	148 $\pm$ 15	570 $\pm$ 30
I98	144 $\pm$ 14	156 $\pm$ 16	174 $\pm$ 17	138 $\pm$ 14	610 $\pm$ 30
I99	168 $\pm$ 17	199 $\pm$ 20	202 $\pm$ 20	188 $\pm$ 19	760 $\pm$ 40
J00	156 $\pm$ 16	184 $\pm$ 18	181 $\pm$ 18	177 $\pm$ 18	700 $\pm$ 30
J20	172 $\pm$ 17	181 $\pm$ 18	182 $\pm$ 18	193 $\pm$ 19	730 $\pm$ 40
J35	174 $\pm$ 17	192 $\pm$ 19	188 $\pm$ 19	179 $\pm$ 18	730 $\pm$ 40
J70	310 $\pm$ 31	318 $\pm$ 32	268 $\pm$ 27	NA	1190 $\pm$ 50
K01	186 $\pm$ 19	183 $\pm$ 18	192 $\pm$ 19	197 $\pm$ 20	760 $\pm$ 40
K02	165 $\pm$ 17	198 $\pm$ 20	203 $\pm$ 20	NA	750 $\pm$ 30
L01	141 $\pm$ 14	167 $\pm$ 17	180 $\pm$ 18	153 $\pm$ 15	640 $\pm$ 30
L02	213 $\pm$ 21	205 $\pm$ 21	230 $\pm$ 23	223 $\pm$ 22	870 $\pm$ 40
L03	141 $\pm$ 14	136 $\pm$ 14	143 $\pm$ 14	133 $\pm$ 13	550 $\pm$ 30
L04	178 $\pm$ 18	175 $\pm$ 17	197 $\pm$ 20	186 $\pm$ 19	740 $\pm$ 40
M02	237 $\pm$ 24	261 $\pm$ 26	261 $\pm$ 26	263 $\pm$ 26	1020 $\pm$ 50
N01	150 $\pm$ 15	144 $\pm$ 14	161 $\pm$ 16	153 $\pm$ 15	610 $\pm$ 30
P01	92 $\pm$ 9	112 $\pm$ 11	113 $\pm$ 11	113 $\pm$ 11	430 $\pm$ 20
P03	117 $\pm$ 12	139 $\pm$ 14	150 $\pm$ 15	139 $\pm$ 14	540 $\pm$ 30
YTL1	127 $\pm$ 13	145 $\pm$ 15	142 $\pm$ 14	127 $\pm$ 13	540 $\pm$ 30
YTL2	113 $\pm$ 11	150 $\pm$ 15	151 $\pm$ 15	134 $\pm$ 13	550 $\pm$ 30
YTL3	97 $\pm$ 10	132 $\pm$ 13	121 $\pm$ 12	110 $\pm$ 11	460 $\pm$ 20
YTL4	101 $\pm$ 10	129 $\pm$ 13	112 $\pm$ 11	103 $\pm$ 10	440 $\pm$ 20
YTL5	154 $\pm$ 15	188 $\pm$ 19	189 $\pm$ 19	166 $\pm$ 17	700 $\pm$ 30

NA :Data Not Available - Lost or destroyed TLD for this collection interval.

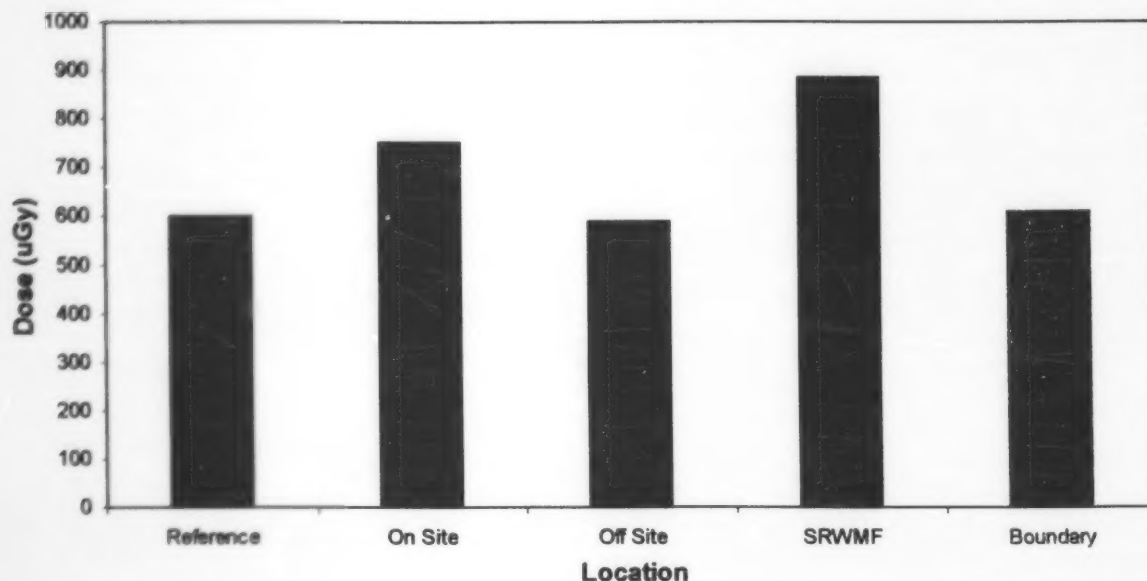


Figure 4.06: Mean TLD Results for 2000

4.06 Airborne Strontiums (GEM)

Since Sr-89,90 emissions are so low, the expected concentration in environmental samples is well below the detection limit.

PLGS gaseous emissions are monitored continuously at their source by the Gaseous Effluent Monitor (GEM). The filters are changed daily and the weekly composite is sent to the lab for analysis. Fifty two sets of these filters were analysed for Sr-89,90. If the release rate warrants, or if significant beta activity is detected in environmental air samples, a Sr-89,90 analysis is performed on those samples.

Strontium-89,90 were not detected in PLGS emissions in 2000.

4.07 Milk

There were no detected radionuclides in milk attributed to PLGS operations.

There are no commercial herds or individual cows producing milk in the Point Lepreau area. The closest herds to PLGS are in Oak Bay (60 km distant), Fredericton Junction (70 km distant), and Hammond River (60 km distant), and the milk from these locations is analysed quarterly. Milk from a commercial dairy is purchased each month from a supermarket in Fredericton. All samples are analysed for gamma emitting radionuclides and tritium.

Table 4.07 is a summary of the detected radionuclides in milk. Cesium-137 was detected in two of the 24 samples collected, at an average concentration of 0.08 Bq/L. The Cs-137 originated from fallout from bomb tests and the Chernobyl accident. Cesium is preferentially absorbed by the cow if there is a dietary deficiency in potassium. Naturally occurring radionuclides (including K-40 at about 50 Bq/L and, occasionally, progeny of uranium and thorium) are also detected in milk. As airborne emissions from PLGS are monitored continuously, and were insignificant all year, neither tritium nor gamma emitting radionuclides attributable to the operation of PLGS would be expected to be detected in these milk samples.

4.08 Well Water

No gamma emitting radionuclides other than those occurring in nature from radon progeny were detected in well water. The beta activity is due to the presence of naturally occurring radionuclides peculiar to certain locations. The H-3 in nine of the 24 samples is most likely due to surface runoff into shallow wells. The source of this H-3 is PLGS emissions.

Water is collected semi-annually from the 12 wells shown in Figure 3.03. Two of these wells are onsite.

Table 4.08 is a summary of the detected radionuclides in well water. Figures 4.07 and 4.08 show the gross beta and H-3 results for each sample. "Less Than" values are plotted for non-detected results. The H-3 measurements were made after samples had been allowed to sit for up to two weeks to avoid radioactive interference from the relatively abundant, but short half-life, radon progeny which are common in most well waters. Tritium originates in the washout into precipitation and subsequent drainage into some of the wells. Rainwater analyses indicate H-3 concentrations ranging from 14 to 360 Bq/L in 37 of 48 samples.

The 1996 Guidelines for Canadian Drinking Water Quality recommend 7000 Bq/L as the maximum acceptable concentration for H-3 in drinking water. The highest average well water H-3 content was less than one percent of the recommended maximum concentration.

As a special project in 2000, 10 additional wells were sampled. These were located just outside the exclusion boundary and belonged to local residents. Results are not presented here but are within the range of the results in Table 4.08.

Table 4.07: Milk (Bq/L)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
Cs-137	24	4.9E-2	3.6E-2 to 5.7E-2	1.1E-1	1/12	1.1E-1 to 1.1E-1	5.3E-2	1/12	5.3E-2 to 5.3E-2
K-40	24	5.7E-1	9.9E-2 to 3.4E+0	5.0E+1	12/12	4.8E+1 to 5.4E+1	5.2E+1	12/12	5.1E+1 to 5.4E+1

*The activity is less than or equal to the Critical Level (99% Confidence Level).



Table 4.07: Milk (Bq/L)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
Cs-137	24	4.9E-2	3.6E-2 to 5.7E-2	1.1E-1	1/12	1.1E-1 to 1.1E-1	5.3E-2	1/12	5.3E-2 to 5.3E-2
K-40	24	5.7E-1	9.9E-2 to 3.4E+0	5.0E+1	12/12	4.8E+1 to 5.4E+1	5.2E+1	12/12	5.1E+1 to 5.4E+1

*The activity is less than or equal to the Critical Level (99% Confidence Level).

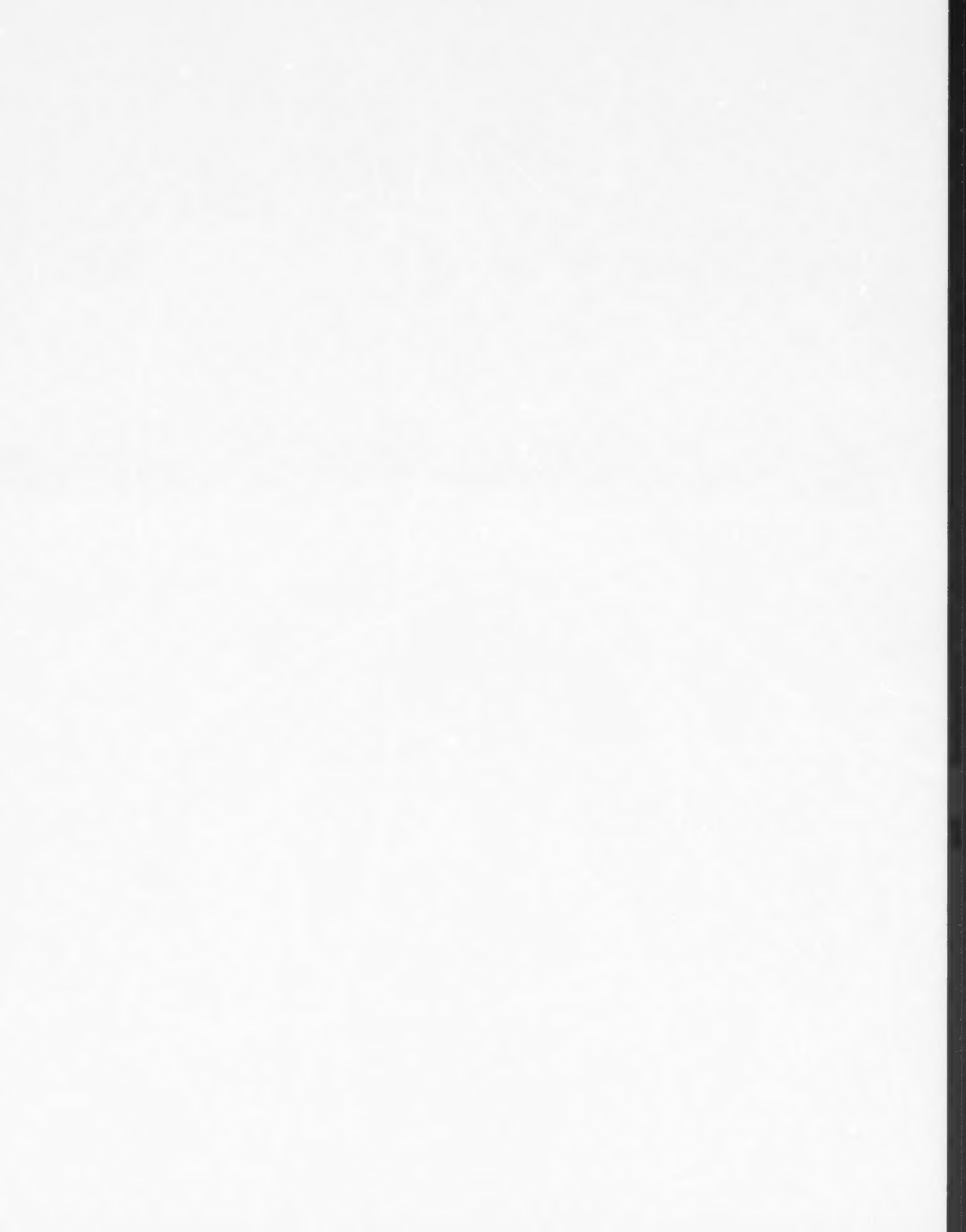


Table 4.08: Well Water (Bq/L)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
<i>Alpha</i>	24	6.1E-2	2.0E-2 to 1.7E-1	1.7E-1	17/22	4.2E-2 to 5.4E-1	*	*	*
<i>Beta</i>	24	4.1E-2	2.3E-2 to 1.0E-1	1.1E-1	21/22	3.6E-2 to 2.8E-1	8.6E-2	2/2	8.5E-2 to 8.7E-2
<i>H-3</i>	24	1.3E+1	1.1E+1 to 1.4E+1	2.2E+1	9/22	1.3E+1 to 3.7E+1	*	*	*

*The activity is less than or equal to the Critical Level (99% Confidence Level).

Table 4.08: Well Water (Bq/L)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
<i>Alpha</i>	24	6.1E-2	2.0E-2 to 1.7E-1	1.7E-1	17/22	4.2E-2 to 5.4E-1	*	*	*
<i>Beta</i>	24	4.1E-2	2.3E-2 to 1.0E-1	1.1E-1	21/22	3.6E-2 to 2.8E-1	8.6E-2	2/2	8.5E-2 to 8.7E-2
<i>H-3</i>	24	1.3E+1	1.1E+1 to 1.4E+1	2.2E+1	9/22	1.3E+1 to 3.7E+1	*	*	*

*The activity is less than or equal to the Critical Level (99% Confidence Level).

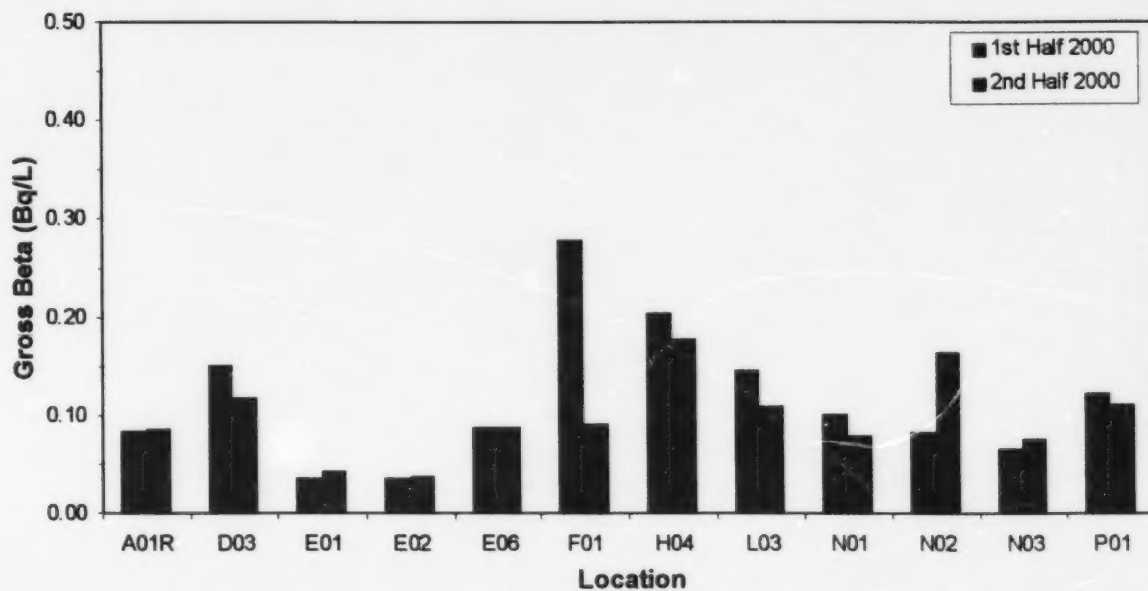


Figure 4.07: Gross Beta in Well Water

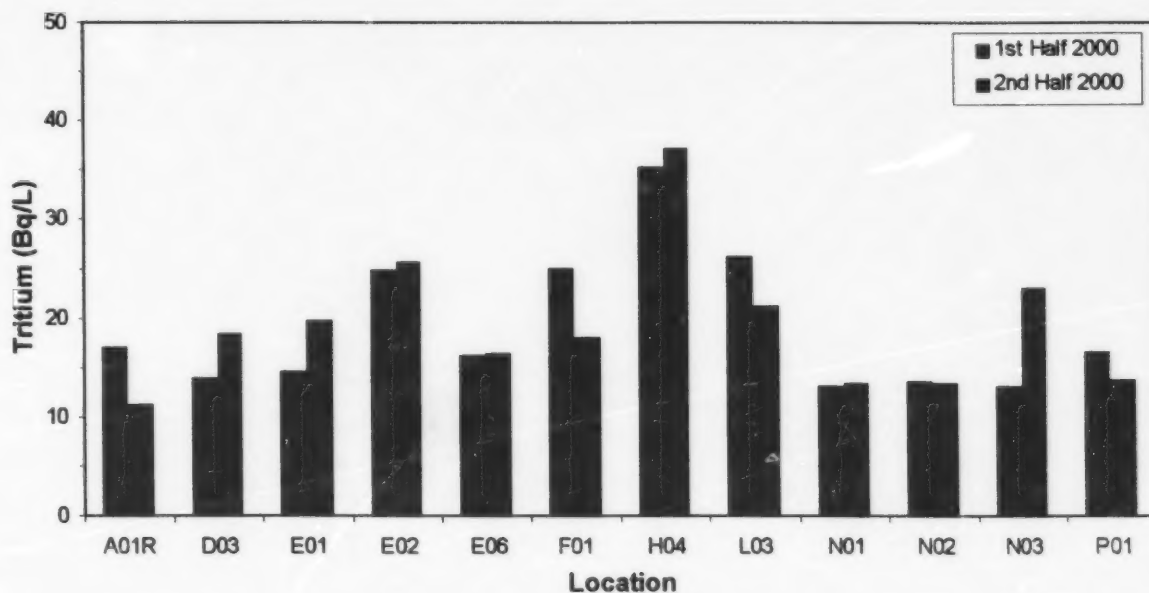


Figure 4.08: Tritium in Well Water

4.09 Pond/Puddle/Surface Water

Tritium, from PLGS emissions, was detected in 5 of the 16 samples. No other radionuclides were detected.

This category includes ponds, lakes, streams, and runoff samples. Most of these samples are from onsite locations. Two important offsite locations are the freshwater supply reservoirs for Saint John and PLGS.

Table 4.09 is a summary of the detected radionuclides in surface water. Detected H-3 activity ranged from 20 to 140 Bq/L. Variability can be due to the size of the reservoir and the residence time at the location. Figure 4.09 shows each sample (location codes are given in Appendix C). "Less Than" values are plotted for non-detected results.

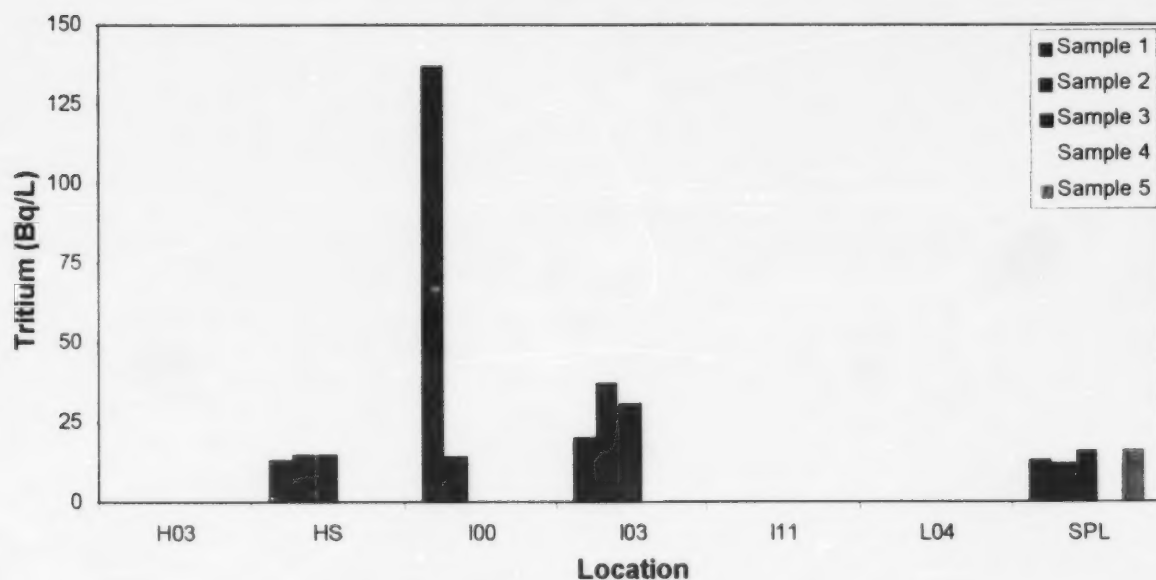


Figure 4.09: Tritium in Pond/Puddle/Surface Water

Table 4.09: Pond/Puddle/Surface Water (Bq/L)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
H-3	16	1.3E+1	1.1E+1 to 1.5E+1	5.6E+1	5/16	2.0E+1 to 1.4E+2	*	*	*

*The activity is less than or equal to the Critical Level (99% Confidence Level).

4.10 Berries

No radionuclides attributable to PLGS emissions were detected in these 12 samples.

Most of these samples were blueberries from the commercial fields at Pennfield. Some local residents provided other species from the Lepreau Peninsula.

It is not unusual to detect Cs-137 in berries throughout North America, although none was seen this year. As in many food samples, naturally occurring K-40 was detected in three samples (see Table 4.10).

4.11 Garden Vegetables

No radionuclides attributable to PLGS emissions were detected in these 32 samples.

Most samples were taken from a local garden in Dipper Harbour (4 km away from PLGS in the predominant wind direction).

As in most food samples, naturally occurring K-40 was detected in 30 samples (see Table 4.11).

4.12 Vegetation (Lichen)

No radionuclides from PLGS were detected in these 17 samples.

Different species of lichen and moss concentrate a wide range of radionuclides, both natural (Be-7 and K-40) and man-made (Cs-137), and are sensitive indicators of radionuclides in the environment. These samples are collected whenever and wherever available from onsite locations.

Only natural Be-7 was detected in several of these samples in 2000 (Table 4.12).

Table 4.10: Berries, Various (Bq/kg)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
K-40	6	2.2E+1	4.8E+0 to 5.8E+1	9.3E+1	3/6	6.6E+1 to 1.4E+2	*	*	*

*The activity is less than or equal to the Critical Level (99% Confidence Level).

Table 4.11: Garden Vegetables (Bq/kg)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
K-40	32	5.4E+1	5.8E+0 to 3.4E+2	1.3E+2	28/32	5.5E+1 to 3.8E+2	*	*	*

*The activity is less than or equal to the Critical Level (99% Confidence Level).

Table 4.12: Vegetation (Bq/kg)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
Be-7	16	4.0E+1	1.1E+1 to 1.0E+2	2.8E+2	15/16	1.1E+2 to 6.2E+2	*	*	*

*The activity is less than or equal to the Critical Level (99% Confidence Level).

4.13 Soil

In 2000, there were no detectable radionuclides that could be attributed to the operation of PLGS in any of the 36 samples analysed.

Soil samples are taken quarterly from the eight air monitoring location sites.

Most samples contained naturally occurring K-40 (68 to 950 Bq/kg), Be-7 (12 to 71 Bq/kg) and Ac-228 (14 to 54 Bq/kg). Twenty-four contained Cs-137 (0.78 to 58 Bq/kg) at typical levels for the region (see Table 4.13). Figure 4.10 shows individual Cs-137 results which seem to be a function of the organic load in the sample. "Less Than" values are plotted for non-detected results. Location codes are shown in Appendix C.

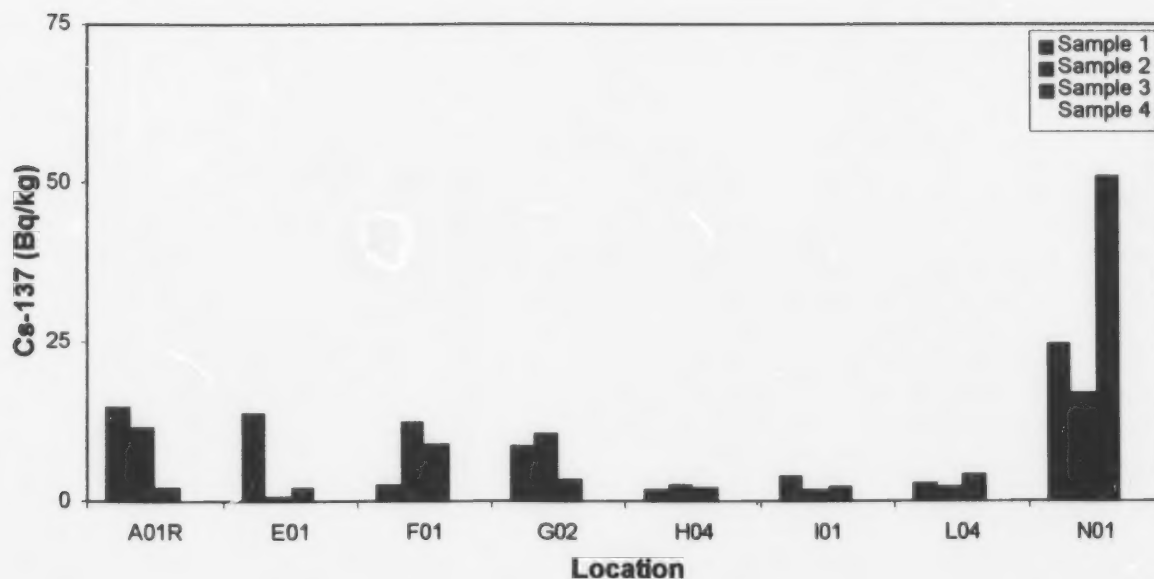


Figure 4.10: Cs-137 in Soil

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Table 4.13: Soil (Bq/kg)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
Be-7	36	1.2E+1	4.3E+0 to 4.2E+1	3.4E+1	11/32	1.2E+1 to 7.1E+1	1.3E+1	1/4	1.3E+1 to 1.3E+1
Cs-137	36	1.9E+0	6.8E-1 to 1.1E+1	1.7E+1	21/32	7.8E-1 to 5.8E+1	1.6E+1	3/4	1.2E+1 to 2.3E+1
Ac-228	36	3.8E+0	1.9E+0 to 2.3E+1	3.5E+1	27/32	1.4E+1 to 5.4E+1	2.7E+1	3/4	2.5E+1 to 2.8E+1
K-40	36	5.3E+1	3.8E+0 to 1.1E+2	5.4E+2	32/32	6.8E+1 to 9.5E+2	4.5E+2	4/4	4.0E+2 to 5.6E+2

*The activity is less than or equal to the Critical Level (99% Confidence Level).

Table 4.13: Soil (Bq/kg)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
Be-7	36	1.2E+1	4.3E+0 to 4.2E+1	3.4E+1	11/32	1.2E+1 to 7.1E+1	1.3E+1	1/4	1.3E+1 to 1.3E+1
Cs-137	36	1.9E+0	6.8E-1 to 1.1E+1	1.7E+1	21/32	7.8E-1 to 5.8E+1	1.6E+1	3/4	1.2E+1 to 2.3E+1
Ac-228	36	3.8E+0	1.9E+0 to 2.3E+1	3.5E+1	27/32	1.4E+1 to 5.4E+1	2.7E+1	3/4	2.5E+1 to 2.8E+1
K-40	36	5.3E+1	3.8E+0 to 1.1E+2	5.4E+2	32/32	6.8E+1 to 9.5E+2	4.5E+2	4/4	4.0E+2 to 5.6E+2

*The activity is less than or equal to the Critical Level (99% Confidence Level).

4.14 Rain Water

Tritium from PLGS was detected in 37 of 48 onsite samples.

Rainwater is collected continuously at the four onsite air monitoring stations (shown in Figure 3.02). The samples are changed approximately monthly, depending on rainfall and freeze up.

Detected H-3 levels spanned 14 to 360 Bq/L, depending on the amount of rainfall. Results are given in Table 4.14 and shown in Figure 4.11. "Less Than" values are plotted for non-detected results.

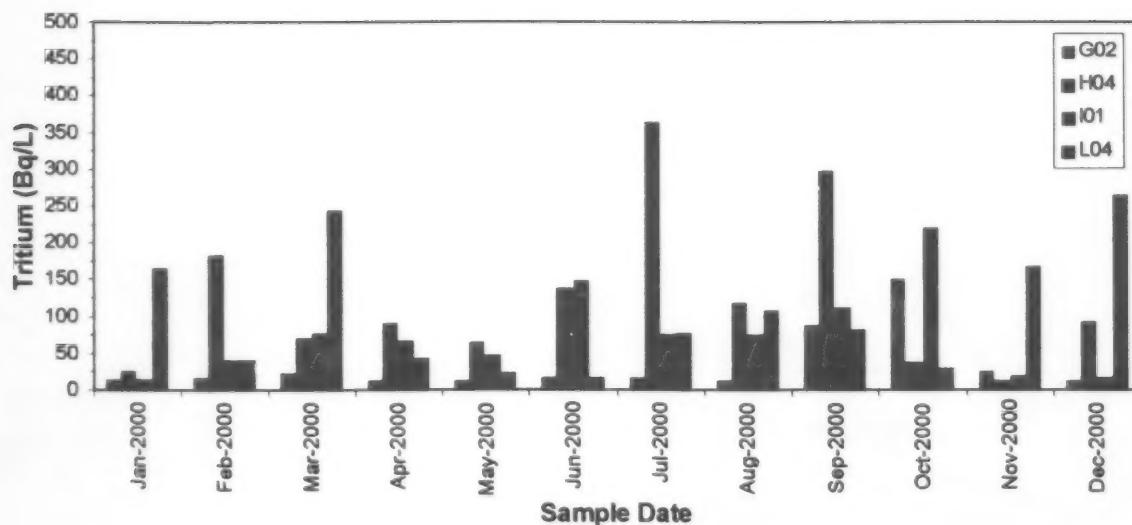


Figure 4.11: Tritium in Rain Water

Table 4.14: Rain Water (Bq/L)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
H-3	48	1.2E+1	1.0E+1 to 1.3E+1	1.1E+2	37/48	1.4E+1 to 3.6E+2			

*The activity is less than or equal to the Critical Level (99% Confidence Level).

4.15 Seawater

In 2000, there were no detectable radionuclides that could be attributed to the operation of PLGS in any of the 22 samples analysed.

Seawater is collected quarterly from three locations close to PLGS and one reference location near Saint John (shown in Figure 3.05). There are at least four samples for each of the locations except C01, which is not a routine site.

In past years, H-3 from PLGS and K-40 from nature have been detected. As seen in Table 4.15, the only radionuclide detected in 2000 is K-40. The Critical Level for H-3 in seawater averages about 12 Bq/L. Calculations suggest that the long term average concentration of tritium in seawater due to releases from PLGS in the liquid pathway was about 70 Bq/L at the out-fall (samples are not usually collected at this point, but are taken at the shoreline nearby). This calculation takes into account the total tritium released over the year, the flow rate of the condenser cooling water (about 24 m³/s), and tidal mixing. A dilution factor of 20 is assumed for tidal mixing at the out-fall during normal coolant flows. For collection further away, a tidal mixing factor of about 40 or even higher, is more realistic. A factor of 40 would result in an average H-3 concentration of about 11 Bq/L of seawater in 2000 at the H03 location.

Table 4.15: Seawater (Bq/L)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
K-40	17	2.6E+0	1.0E+0 to 6.3E+0	1.1E+1	12/12	6.4E+0 to 1.4E+1	9.8E+0	5/5	8.5E+0 to 1.2E+1

*The activity is less than or equal to the Critical Level (99% Confidence Level).

4.16 Clams

Most of the seafood analysed in the environmental program contain detectable levels of K-40 (see Table 4.16). No contribution of gamma emitting radionuclides from the operation of Point Lepreau was detected in 2000.

The nature of the fishery has changed over the last few years. The inshore fishery often faces restrictions placed upon the harvesting of shellfish, either for conservation of stocks or because of bacterial contamination, algal blooms, or other natural cycles. This restricts the availability of some sample types for analysis. Sample locations are shown in Figure 3.05.

4.17 Fish

One sample was available for analysis in 2000 (see Table 4.17). The nature of the fishery has changed over the last few years. Herring and mackerel, which used to make up the bulk of the analyses, are now less available for analysis. The fish category now tends to be made up of dogfish, cod, hake and sardines, if they are available at all.

4.18 Lobster

Most of the seafood analysed in the environmental program contain detectable levels of K-40 (see Table 4.18). No contribution of gamma emitting radionuclides from the operation of Point Lepreau was detected in 2000, even though several of the samples were collected close to the cooling water outflow from PLGS (Figure 3.05).

4.19 Periwinkles

Most of the seafood analysed in the environmental program contain detectable levels of K-40 (see Table 4.19). No contribution of gamma emitting radionuclides from the operation of Point Lepreau was detected in 2000. Sample locations are shown in Figure 3.05.

4.20 Aquaculture Salmon

The aquaculture salmon industry is important to the area west of PLGS. Potassium-40 is detected in all of these samples (see Table 4.20). As liquid emissions from PLGS are monitored continuously, and were insignificant all year, no radionuclides attributable to the operation of PLGS would be expected to be detected in these remote samples.

Table 4.16: Clams, Edible Raw Mass (Bq/kg)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
K-40	9	4.7E+1	5.8E+0 to 1.3E+2	1.5E+2	8/9	4.8E+1 to 2.3E+2	*	*	*

*The activity is less than or equal to the Critical Level (99% Confidence Level).

Table 4.17: Fish, Various, Edible, Raw Mass (Bqkg)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
K-40	1	4.9E+1	4.9E+1 to 4.9E+1	1.4E+2	1/1	1.4E+2 to 1.4E+2	*	*	*

*The activity is less than or equal to the Critical Level (99% Confidence Level).

Table 4.18: Lobster, Edible, Cooked Mass (Bq/kg)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
K-40	6	1.9E+1	6.7E+0 to 5.8E+1	8.9E+1	6/6	6.1E+1 to 1.1E+2	*	*	*

*The activity is less than or equal to the Critical Level (99% Confidence Level).

Table 4.19: Periwinkles, Edible, Raw Mass (Bq/kg)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
K-40	12	5.4E+1	2.1E+1 to 1.2E+2	1.6E+2	11/12	8.0E+1 to 3.2E+2	*	*	*

*The activity is less than or equal to the Critical Level (99% Confidence Level).

Table 4.20: Aquaculture Salmon, Raw Mass (Bq/kg)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
K-40	2	3.6E+0	2.3E+0 to 4.9E+0	1.6E+2	2/2	1.6E+2 to 1.6E+2	*	*	*

*The activity is less than or equal to the Critical Level (99% Confidence Level).

4.21 Scallops

Most of the seafood analysed in the environmental program contain detectable levels of K-40 (see Table 4.21). Scallops may also contain detectable quantities of Ac-228. No contribution of gamma emitting radionuclides from the operation of Point Lepreau was detected in 2000.

The inshore fishery often faces restrictions or total bans placed upon the harvesting of scallops for conservation of stocks. This affects the number of samples available for analysis.

4.22 Crab

There was no active crab fishery in the local area and there were no samples available.

4.23 Dulse

Most of the seafood analysed in the environmental program contain detectable levels of K-40. No contribution of gamma emitting radionuclides from the operation of Point Lepreau was detected in 2000 (see Table 4.22).

Dulse is an edible seaweed that is a popular snack food in the area. Eight samples were collected in 2000 at locations shown in Figure 3.05.

4.24 Other Sea Plants

All of the sea plants analysed in the environmental program contain K-40. No contribution of gamma emitting radionuclides from the operation of Point Lepreau was detected in 2000.

Sea plants other than dulse are analysed. Various species of seaweed (for example, *Ascophylum*) occur on the rocks on the Point Lepreau peninsula and are collected from time to time. Three of the 14 samples collected contained Be-7, a cosmogenic radionuclide. All contained naturally occurring K-40 at an average of 180 Bq/kg (see Table 4.23).

Table 4.21: Scallops, Edible, Raw Mass (Bq/kg)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
K-40	1	3.5E+0	3.5E+0 to 3.5E+0	1.2E+2	1/1	1.2E+2 to 1.2E+2	*	*	*

*The activity is less than or equal to the Critical Level (99% Confidence Level).

Table 4.22: Dulse, Wet Mass (Bq/kg)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
K-40	8	5.9E+1	1.4E+1 to 1.4E+2	4.8E+2	8/8	2.7E+2 to 7.3E+2	*	*	*

*The activity is less than or equal to the Critical Level (99% Confidence Level).

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Table 4.23: Sea Plants Wet Mass (Bq/kg)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
Be-7	14	4.5E+0	2.4E+0 to 7.4E+0	9.6E+0	3/13	5.5E+0 to 1.3E+1	*	*	*
K-40	14	1.6E+1	2.7E+0 to 4.6E+1	1.8E+2	13/13	1.4E+2 to 2.4E+2	1.4E+2	1/1	1.4E+2 to 1.4E+2

*The activity is less than or equal to the Critical Level (99% Confidence Level).

Table 4.23: Sea Plants Wet Mass (Bq/kg)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
Be-7	14	4.5E+0	2.4E+0 to 7.4E+0	9.6E+0	3/13	5.5E+0 to 1.3E+1	*	*	*
K-40	14	1.6E+1	2.7E+0 to 4.6E+1	1.8E+2	13/13	1.4E+2 to 2.4E+2	1.4E+2	1/1	1.4E+2 to 1.4E+2

*The activity is less than or equal to the Critical Level (99% Confidence Level).

4.25 Sediment

No contribution of gamma emitting radionuclides from the operation of Point Lepreau was detected in 2000.

Sediments are collected quarterly from ten locations (shown in Figure 3.05). All samples contain radioactivity from naturally occurring radionuclides (K-40 from the natural potassium in feldspar, a common mineral) and from the diminishing levels of Cs-137 fallout from bomb tests since the 1950s. A small additional Cs-137 component from Chernobyl was added to this reservoir in 1986. Actinium-228 (radioactive progeny of naturally occurring Th-232), and Be-7 (of cosmogenic origin) commonly occur in sediments. Finer grain sediments have a higher radioactivity content than coarse sediments.

See Table 4.24 for a summary of the data. Figure 4.12 shows the Cs-137 concentration for each location. "Less Than" values are plotted for non-detected results. Location codes are listed in Appendix C

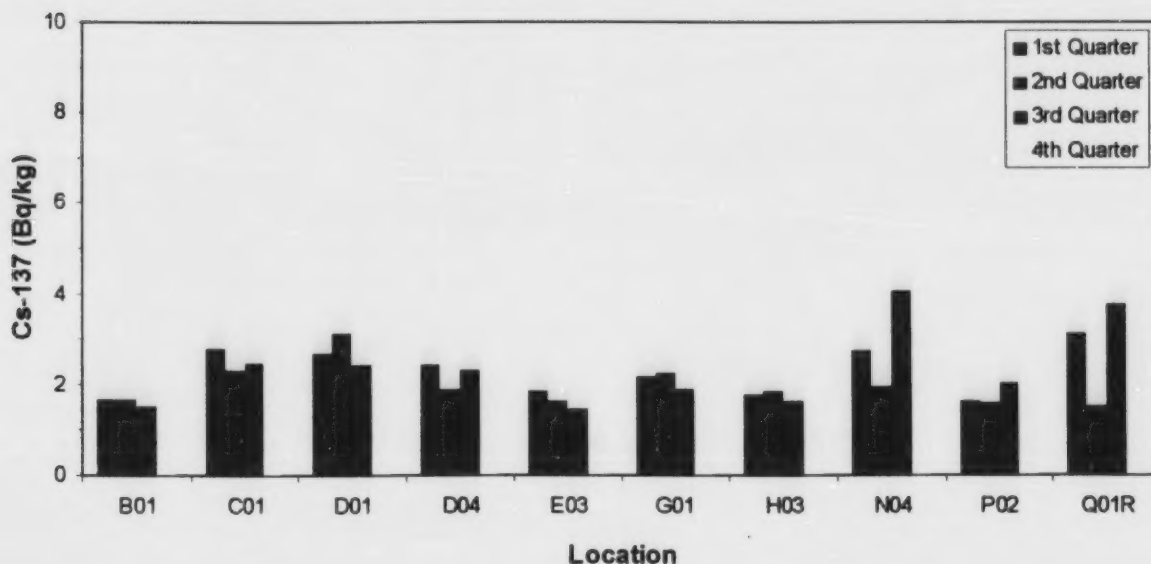


Figure 4.12: Cs-137 in Sediment

Table 4.24: Sediment (Bq/kg)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
Be-7	40	7.8E+0	3.3E+0 to 1.4E+0	2.7E+1	12/36	6.9E+0 to 5.9E+1	5.5E+1	3/4	5.0E+1 to 6.7E+1
Cs-137	40	1.1E+0	7.2E-1 to 2.1E+0	2.7E+0	6/36	2.3E+0 to 4.1E+0	1.5E+0	1/4	1.5E+0 to 1.5E+0
Ac-228	40	2.5E+0	1.2E+0 to 4.3E+0	2.1E+1	31/36	1.1E+1 to 3.9E+1	2.5E+1	4/4	2.2E+1 to 2.8E+1
K-40	40	4.2E+1	2.7E+0 to 1.0E+2	5.1E+2	36/36	4.1E+2 to 6.5E+2	5.4E+2	4/4	4.4E+2 to 5.9E+2

*The activity is less than or equal to the Critical Level (99% Confidence Level).

Table 4.24: Sediment (Bq/kg)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
Be-7	40	7.8E+0	3.3E+0 to 1.4E+0	2.7E+1	12/36	6.9E+0 to 5.9E+1	5.5E+1	3/4	5.0E+1 to 6.7E+1
Cs-137	40	1.1E+0	7.2E-1 to 2.1E+0	2.7E+0	6/36	2.3E+0 to 4.1E+0	1.5E+0	1/4	1.5E+0 to 1.5E+0
Ac-228	40	2.5E+0	1.2E+0 to 4.3E+0	2.1E+1	31/36	1.1E+1 to 3.9E+1	2.5E+1	4/4	2.2E+1 to 2.8E+1
K-40	40	4.2E+1	2.7E+0 to 1.0E+2	5.1E+2	36/36	4.1E+2 to 6.5E+2	5.4E+2	4/4	4.4E+2 to 5.9E+2

*The activity is less than or equal to the Critical Level (99% Confidence Level).



4.26 Gamma Surveys (Beaches)

Environmental gamma survey measurements are made in the inter-tidal zone on beaches in the Point Lepreau area and at the reference location 28 km to the east northeast (Figure 3.05). Although TLDs are preferred in measuring such exposures since they span the entire year and provide integrated measurements, they cannot be used in these locations. Radiation values measured in 2000 were consistent with those measured prior to station start-up in 1982. These are summarised in Table 4.25

Table 4.25: Beach Surveys - Inter-tidal Zone - Ion Chamber ($\mu\text{Sv/h}$)

<i>Location</i>	<i>1st Quarter</i>	<i>2nd Quarter</i>	<i>3rd Quarter</i>	<i>4th Quarter</i>
B01	0.08	0.08	0.08	0.07
C01	0.10	0.08	0.08	0.07
D01	0.10	0.08	0.07	0.08
D04	0.09	0.08	0.08	0.08
E03	0.08	0.09	0.07	0.08
G01	0.12	0.10	0.07	0.09
H03	0.11	0.09	0.10	0.08
N04	0.12	0.07	0.09	0.08
P02	0.10	0.07	0.08	0.07
Q01R	0.07	0.08	0.07	0.09

*Although two decimal places are quoted, none of the determinations has this degree of precision nor of accuracy. The data are quoted to two figures just as they are estimated at each location. They should be regarded as about 0.1 to 0.2 $\mu\text{Sv/h}$.

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Environmental gamma survey measurements are made in the inter-tidal zone on beaches in the Point Lepreau area and at the reference location 28 km to the east northeast (Figure 3.05). Although TLDs are preferred in measuring such exposures since they span the entire year and provide integrated measurements, they cannot be used in these locations. Radiation values measured in 2000 were consistent with those measured prior to station start-up in 1982. These are summarised in Table 4.25

Table 4.25: Beach Surveys - Inter-tidal Zone - Ion Chamber ($\mu\text{Sv/h}$)

<i>Location</i>	<i>1st Quarter</i>	<i>2nd Quarter</i>	<i>3rd Quarter</i>	<i>4th Quarter</i>
B01	0.08	0.08	0.08	0.07
C01	0.10	0.08	0.08	0.07
D01	0.10	0.08	0.07	0.08
D04	0.09	0.08	0.08	0.08
E03	0.08	0.09	0.07	0.08
G01	0.12	0.10	0.07	0.09
H03	0.11	0.09	0.10	0.08
N04	0.12	0.07	0.09	0.08
P02	0.10	0.07	0.08	0.07
Q01R	0.07	0.08	0.07	0.09

*Although two decimal places are quoted, none of the determinations has this degree of precision nor of accuracy. The data are quoted to two figures just as they are estimated at each location. They should be regarded as about 0.1 to 0.2 $\mu\text{Sv/h}$.

4.27 Liquid Strontiums (LEM)

Since Sr-89,90 releases are so low, the expected concentration in environmental samples is well below the detection limit.

PLGS liquid emissions are measured by the Liquid Effluent Monitor (LEM) before their release. A monthly composite is sent to the lab for analyses. Twelve of these composites were analysed for Sr-89,90. If the release rate warrants, a Sr-89,90 analysis is performed on seawater samples.

Strontium-90 was detected in several of these LEM samples at a level close to the detection limit. This translated into $1.1\text{E}+06$ Bq released in 2000, compared with an annual DEL of $1.8\text{E}+14$ Bq. No further analyses were indicated. See Figure 4.13.

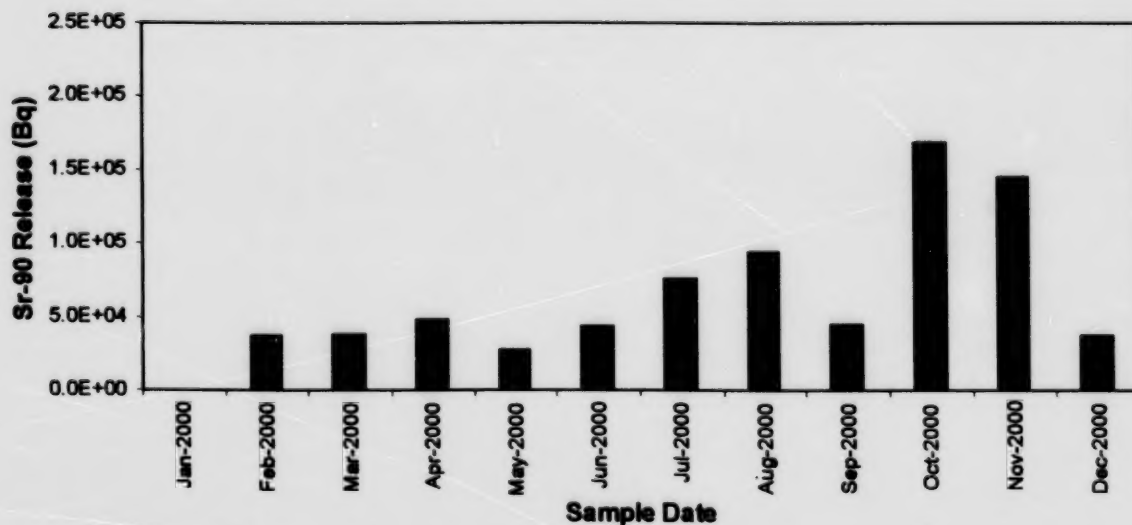


Figure 4.13: Sr-90 Releases (measured at source)

4.28 Bore Hole Water (SRWMF)

Tritium from PLGS was detected in 55 of the 56 samples analysed. No other radionuclides attributable to the operation of PLGS were detected.

Water from 17 bore holes on the SRWMF site (Phase 1 and 2) are collected each quarter (a total of 68 samples, if all contain sufficient water to be sampled).

Tritium concentrations averaged 97 Bq/L, ranging up to 540 Bq/L. Tritium originates in the washout into precipitation and subsequent drainage into some of the bore holes (rainwater analyses indicate H-3 concentrations ranging from 14 to 360 Bq/L in 37 of 48 samples). Contamination of some of the bore holes by surface runoff is unavoidable when the bore holes are first opened because of standing-water covering the well cap. See Tables 4.26 and 4.27. Figure 4.14 shows the H-3 activity at each bore hole for each sample. Locations I00A and I00B are the closest to the SRWMF- Phase 1 structures and may be affected by the higher H-3 levels associated with them. "Less Than" values are plotted for non-detected results.

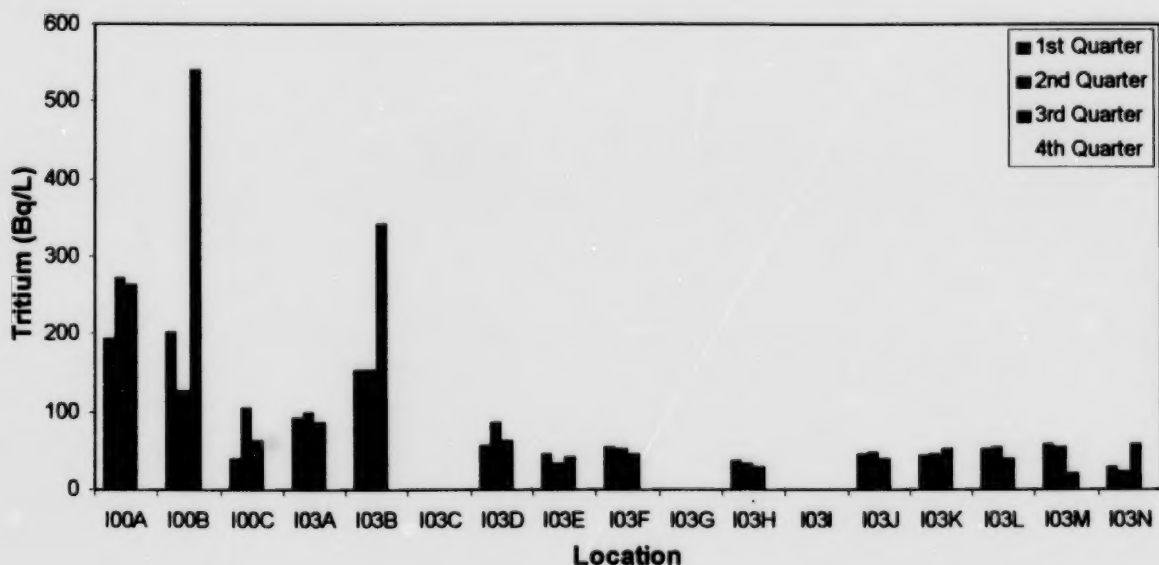


Figure 4.14: Tritium in Bore Holes

Table 4.26: Bore Hole Water SRWMF - Phase 1 (Bq/L)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
H-3	12	1.3E+1	1.1E+1 to 1.6E+1	2.1E+2	12/12	4.0E+1 to 5.4E+2	*	*	*

*The activity is less than or equal to the Critical Level (99% Confidence Level).

Table 4.27: Bore Hole Water SRWMF - Phase 2 (Bq/L)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
H-3	44	1.3E+1	1.1E+1 to 1.4E+1	6.5E+1	43/44	1.9E+1 to 3.4E+2	*	*	*

*The activity is less than or equal to the Critical Level (99% Confidence Level).

4.29 Parshall Flume (SRWMF)

Tritium from PLGS was detected in 104 of 106 samples reaching $8.9\text{E}+03$ Bq/L, with a mean value of about $8.0\text{E}+02$ Bq/L. No other radionuclides attributable to the operation of PLGS were detected.

Rainwater at the SRWMF (Phase 1 and 2) is obtained from drainage channels (flumes) constructed to collect surface runoff from these areas. Samples are collected and analysed on a weekly basis. There is little or no flow into or out of these collection locations during the winter months and values for H-3 tend to vary little from one week to the next except after heavy rain. The average value at Phase 2 is $8.9\text{E}+01$ Bq/L, much less than $1.5\text{E}+03$ Bq/L at Phase 1. This indicates possible groundwater dilution of the surface runoff to the flume or a developing problem with the Phase 1 structures. See Tables 4.28 and 4.29. Figure 4.15 compares the H-3 in the samples from the two facilities.

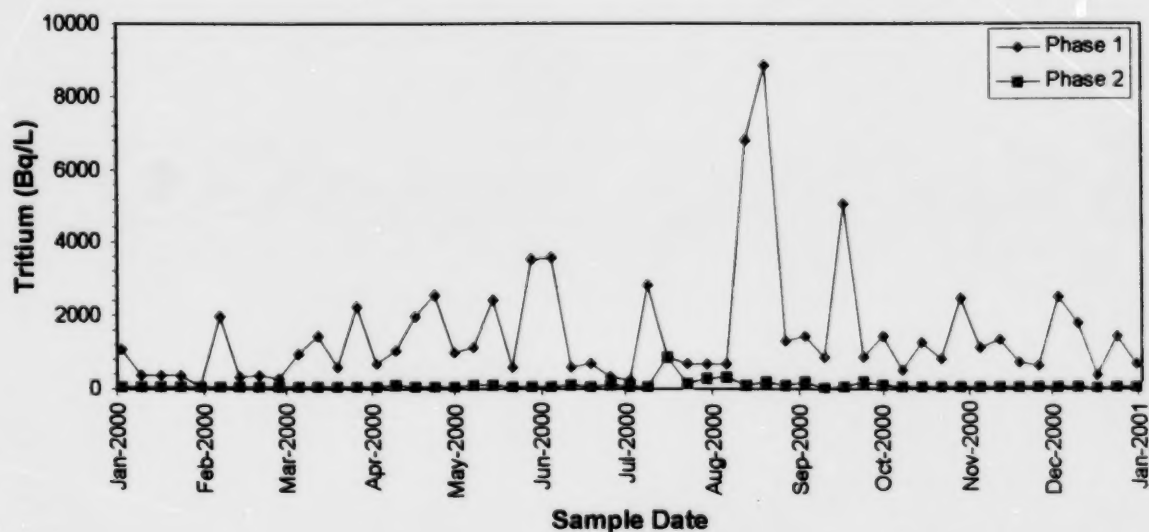


Figure 4.15: Tritium in Parshall Flumes

Table 4.28: Parshall Flume SRWMF - Phase 1 (Bq/L)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
H-3	53	1.2E+1	1.0E+1 to 1.5E+1	1.5E+3	53/53	3.2E+1 to 8.9E+3	*	*	*

*The activity is less than or equal to the Critical Level (99% Confidence Level).

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Table 4.29: Parshall Flume SRWMF - Phase 2 (Bq/L)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
H-3	53	1.2E+1	1.0E+1 to 1.3E+1	8.9E+1	51/53	2.8E+1 to 8.5E+2	*	*	*
K-40	53	2.9E+0	1.9E+0 to 5.4E+0	4.1E+0	1/53	4.1E+0 to 4.1E+0	*	*	*

*The activity is less than or equal to the Critical Level (99% Confidence Level).

Table 4.29: Parshall Flume SRWMF - Phase 2 (Bq/L)

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
H-3	53	1.2E+1	1.0E+1 to 1.3E+1	8.9E+1	51/53	2.8E+1 to 8.5E+2	*	*	*
K-40	53	2.9E+0	1.9E+0 to 5.4E+0	4.1E+0	1/53	4.1E+0 to 4.1E+0	*	*	*

*The activity is less than or equal to the Critical Level (99% Confidence Level).



4.30 Drop-off TLDs (SRWMF - Phase 2)

The measured radiation decreases as the distance from the SRWMF - Phase 2 increases.

Dosimeters are placed in two directions from the boundary fence of Phase 2 to measure drop-off of radiation with distance from the filled dry fuel storage canisters, to about 200 metres. Results are presented in Table 4.30.

There were 86 concrete canisters filled to the end of 2000 with 46 440 used-fuel bundles. Radiation drop-off measurements (Figure 4.16) with increasing distance away from the fence show distinct differences. The 'A' direction (mostly swamp after 20 m from the fence) covers drop-off to the north-east away from the perimeter fence. The 'B' direction (mostly rock with some shallow sandy overburden) covers drop-off to the north-west away from the perimeter (after 75 m the TLDs are shielded from the facility by the high ground).

Table 4.30: TLD, Drop-off (μGy)

Location	Dose ($\mu\text{Gy} \pm 10\%$)				
	1 st Quarter	2 nd Quarter	3 rd Quarter	4 th Quarter	Year
A 5m	205 $\pm$ 21	240 $\pm$ 24	224 $\pm$ 22	220 $\pm$ 22	890 $\pm$ 40
A 10m	200 $\pm$ 20	215 $\pm$ 22	227 $\pm$ 23	219 $\pm$ 22	860 $\pm$ 40
A 15m	159 $\pm$ 16	186 $\pm$ 19	180 $\pm$ 18	171 $\pm$ 17	700 $\pm$ 30
A 20m	104 $\pm$ 10	131 $\pm$ 13	124 $\pm$ 12	117 $\pm$ 12	480 $\pm$ 20
A 25m	101 $\pm$ 10	116 $\pm$ 12	110 $\pm$ 11	126 $\pm$ 13	450 $\pm$ 20
A 50m	88 $\pm$ 9	102 $\pm$ 10	104 $\pm$ 10	92 $\pm$ 9	390 $\pm$ 20
A 75m	81 $\pm$ 8	109 $\pm$ 11	115 $\pm$ 11	100 $\pm$ 10	400 $\pm$ 20
A 100m	76 $\pm$ 8	92 $\pm$ 9	96 $\pm$ 10	94 $\pm$ 9	360 $\pm$ 20
A 118m	100 $\pm$ 10	128 $\pm$ 13	131 $\pm$ 13	128 $\pm$ 13	490 $\pm$ 20
B 5m	214 $\pm$ 21	316 $\pm$ 32	304 $\pm$ 30	287 $\pm$ 29	1120 $\pm$ 60
B 10m	207 $\pm$ 21	280 $\pm$ 28	280 $\pm$ 28	258 $\pm$ 26	1030 $\pm$ 50
B 15m	197 $\pm$ 20	228 $\pm$ 23	244 $\pm$ 24	240 $\pm$ 24	910 $\pm$ 50
B 20m	190 $\pm$ 19	221 $\pm$ 22	245 $\pm$ 25	221 $\pm$ 22	880 $\pm$ 40
B 25m	170 $\pm$ 17	225 $\pm$ 22	225 $\pm$ 22	212 $\pm$ 21	830 $\pm$ 40
B 50m	143 $\pm$ 14	192 $\pm$ 19	195 $\pm$ 19	170 $\pm$ 17	700 $\pm$ 40
B 75m	153 $\pm$ 15	182 $\pm$ 18	169 $\pm$ 17	159 $\pm$ 16	660 $\pm$ 30
B 100m	178 $\pm$ 18	201 $\pm$ 20	207 $\pm$ 21	180 $\pm$ 18	770 $\pm$ 40
B 150m	153 $\pm$ 15	181 $\pm$ 18	181 $\pm$ 18	168 $\pm$ 17	680 $\pm$ 30
B 200m	161 $\pm$ 16	182 $\pm$ 18	185 $\pm$ 19	165 $\pm$ 17	690 $\pm$ 30

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	1 st Quarter	2 nd Quarter	3 rd Quarter	4 th Quarter	Year
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B 20m	190 $\pm$ 19	221 $\pm$ 22	245 $\pm$ 25	221 $\pm$ 22	880 $\pm$ 40
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B 50m	143 $\pm$ 14	192 $\pm$ 19	195 $\pm$ 19	170 $\pm$ 17	700 $\pm$ 40
B 75m	153 $\pm$ 15	182 $\pm$ 18	169 $\pm$ 17	159 $\pm$ 16	660 $\pm$ 30
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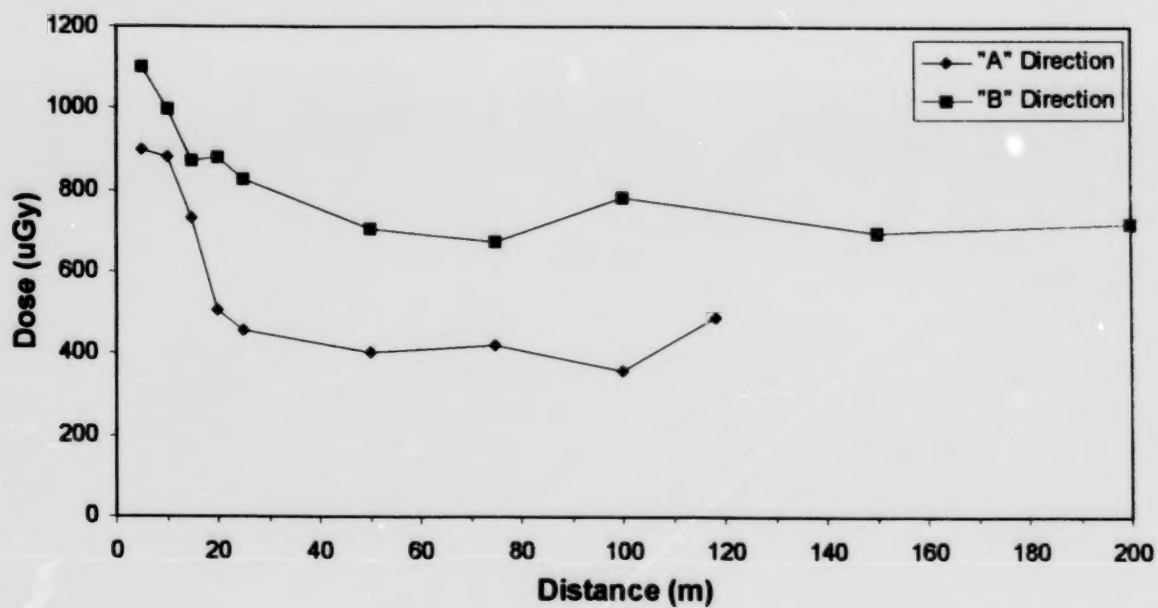


Figure 4.16: Drop-off TLDs



4.31 Hemlock Knoll Regional Sanitary Landfill

In December, 1999, PLGS began disposing of its non-active waste at the public landfill facility. A monitoring program was established prior to the first shipment. It includes sampling of water from the leachate, bore holes and various holding ponds; sampling of the soil and gamma surveys of the disposal cell surface; and dosimeter placement at key locations.

There were 90 water samples, 32 soil samples, 32 gamma meter measurements and 20 TLD results. Tritium was detected in two of the 90 water samples. Table 4.31 summarises the gamma survey results and Table 4.32 summarises the water sample results. There were no other radionuclides detected in the water or soil samples, other than naturally occurring isotopes which are not reported here. TLD results appear in Table 4.06 (location codes YTL1 to YTL5).

Table 4.31: Gamma Surveys - Hemlock Knoll Regional Sanitary Landfill Ion Chamber ($\mu\text{Sv/h}$)

<i>Location</i>	<i>2nd Quarter</i>	<i>3rd Quarter #1</i>	<i>3rd Quarter #2</i>	<i>4th Quarter</i>
YODC1	0.11	0.09	0.09	0.10
YODC2	0.10	0.08	0.08	0.11
YODC3	0.12	0.07	0.11	0.11
YODC4	0.11	0.09	0.11	0.11
YODC5	0.12	0.08	0.12	0.12
YODC6	0.11	0.08	0.07	0.12
YYW1	0.15	0.08	0.09	0.11
YYW2	0.12	0.10	0.08	0.11

*Although two decimal places are quoted, none of the determinations has this degree of precision nor of accuracy. The data are quoted to two figures just as they are estimated at each location. They should be regarded as about 0.1 to 0.2 $\mu\text{Sv/h}$.

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YODC1	0.11	0.09	0.09	0.10
YODC2	0.10	0.08	0.08	0.11
YODC3	0.12	0.07	0.11	0.11
YODC4	0.11	0.09	0.11	0.11
YODC5	0.12	0.08	0.12	0.12
YODC6	0.11	0.08	0.07	0.12
YYW1	0.15	0.08	0.09	0.11
YYW2	0.12	0.10	0.08	0.11

*Although two decimal places are quoted, none of the determinations has this degree of precision nor of accuracy. The data are quoted to two figures just as they are estimated at each location. They should be regarded as about 0.1 to 0.2 $\mu\text{Sv/h}$.

Table 4.32: Liquid (Bq/L) Hemlock Knoll Regional Sanitary Landfill

Analysis Type	Total Number	Critical Level		Indicator Stations			Reference Station		
		Mean	Range	Mean	Frequency	Range	Mean	Frequency	Range
H-3	90	6.1E+1	5.4E+1 to 9.3E+1	7.2E+1	2/90	6.3E+1 to 8.1E+1			

*The activity is less than or equal to the Critical Level (99% Confidence Level).

4.32 Meteorological Data

A problem was discovered in the meteorological data for the years 1992 to 2000: the temperature reading from the 42 metre elevation (at the Point Lepreau Generating Station tower) contained a bias which affected the calculation of the Pasquill Stability factor.

The meteorological data for 2000, and a compilation of the available 1986 to 2000 data, have this information removed and are presented in Tables 4.33 and 4.34. Data were collected hourly. Wind Rose data for 2000 are presented in Figure 4.17 and a pie-plot of the average percentage frequency of Pasquill stability classes for the years from 1986 to 1991 in the Point Lepreau area is presented in Figure 4.18.

Table 4.33: Meteorological Data For Point Lepreau (2000)

Month	Temperature (Degrees Celsius) 10 Metre Tower Data					Wind Direction* (Relative %) 42 Metre Tower Data							
	Avg	Mean Daily		Extreme		%Observations from							
		Max	Min	Max	Min	N	NE	E	SE	S	SW	W	NW
January	-4.0	0.1	-8.5	11.2	-19.1	11	10	4	5	9	8	32	22
February	-4.8	-0.4	-9.0	7.8	-17.5	10	5	1	5	9	23	31	15
March	2.3	5.5	-0.8	10.3	-8.0	17	25	6	8	25	5	4	10
April	4.6	7.4	2.1	11.8	-1.7	9	11	5	8	25	20	20	3
May	8.4	12.0	5.7	21.4	0.4	11	25	4	7	19	15	8	11
June	12.1	16.3	9.2	26.0	4.0	7	6	5	12	27	24	14	5
July	14.0	17.6	11.5	22.5	10.4	5	9	5	12	28	24	12	6
August	16.2	19.9	12.6	23.7	12.0	10	3	0	4	29	34	8	14
September	14.3	18.4	11.3	23.9	5.1	14	15	3	4	23	18	9	15
October	DATA UNAVAILABLE					DATA UNAVAILABLE							
November	2.0	4.5	-1.1	11.2	-10.1	21	11	5	1	7	7	23	25
December	-4.2	0.0	-8.3	14.2	-17.6	8	8	3	5	3	6	42	25
Annual	Mean 3.7	Mean 7.3	Mean 0.3	Extreme 26.0	Extreme -19.1	11	13	4	7	17	15	20	14
Years	1	1	1	1	1	1	1	1	1	1	1	1	1

*Each compass direction covers ± 22.5 degrees

Table 4.34: Meteorological Data for Point Lepreau (average 1986 to 1991)

Month	Temperature (Degrees Celsius)					Wind Direction* Relative % % Observation From								Relative % Pasquill Stability Classes							% UNAV
	Mean Daily		Extreme		Avg	N	NE	E	SE	S	SW	W	NW	A	B	C	D	E	F	G	
	Max	Min	Max	Min																	
January	-4.9	-0.8	-8.9	7.2	-25.3	11	10	4	5	10	19	18	23	19	9	8	26	22	12	5	3
February	-5.4	-1.8	-9.4	7.3	-21.9	16	8	3	4	11	22	15	23	22	11	11	23	19	9	5	1
March	-1.5	1.5	-4.7	13.5	-24.9	19	13	4	5	15	17	9	19	16	8	8	25	25	12	1	
April	3.3	5.9	1.1	16.4	-4.2	20	25	6	6	17	13	8	5	12	5	7	25	33	12	6	15
May	7.9	11.2	5.5	25.6	-0.7	13	19	6	6	22	22	7	5	8	4	6	21	32	17	13	18
June	11.4	14.6	9.0	26.1	4.1	8	17	7	6	20	23	12	8	4	2	3	16	36	23	16	14
July	14.4	17.3	12.0	25.2	6.9	5	12	5	7	25	31	10	6	2	1	2	11	31	27	27	9
August	14.8	17.5	12.7	25.0	8.3	6	10	5	8	23	27	14	8	2	1	1	9	29	33	26	7
September	12.0	14.4	9.9	26.3	1.1	8	9	4	6	20	24	16	14	5	2	3	18	34	25	13	6
October	8.4	10.7	6.1	18.9	-1.7	13	10	7	9	19	18	14	11	5	4	5	27	30	17	12	3
November	2.8	5.7	-0.2	14.5	-13.7	13	9	4	7	11	13	22	23	9	5	8	34	25	15	4	1
December	-4.0	-0.1	-8.0	11.1	-21.1	13	6	5	3	7	13	25	28	18	11	11	27	21	9	3	5
Period	Mean 4.9	Mean 8.1	Mean 2.2	Mean 26.3	Extreme -25.3	12	12	5	6	17	20	14	15	10	5	6	22	28	18	11	7
Years	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

42 Metre Tower data

*Each compass direction covers ± 22.5 degrees

4.32 Meteorological Data

A problem was discovered in the meteorological data for the years 1992 to 2000: the temperature reading from the 42 metre elevation (at the Point Lepreau Generating Station tower) contained a bias which affected the calculation of the Pasquill Stability factor.

The meteorological data for 2000, and a compilation of the available 1986 to 2000 data, have this information removed and are presented in Tables 4.33 and 4.34. Data were collected hourly. Wind Rose data for 2000 are presented in Figure 4.17 and a pie-plot of the average percentage frequency of Pasquill stability classes for the years from 1986 to 1991 in the Point Lepreau area is presented in Figure 4.18.

Table 4.33: Meteorological Data For Point Lepreau (2000)

Month	Temperature (Degrees Celsius) 10 Metre Tower Data					Wind Direction* (Relative %) 42 Metre Tower Data							
	Avg	Mean Daily		Extreme		%Observations from							
		Max	Min	Max	Min	N	NE	E	SE	S	SW	W	NW
January	-4.0	0.1	-8.5	11.2	-19.1	11	10	4	5	9	8	32	22
February	-4.8	-0.4	-9.0	7.8	-17.5	10	5	1	5	9	23	31	15
March	2.3	5.5	-0.8	10.3	-8.0	17	25	6	8	25	5	4	10
April	4.6	7.4	2.1	11.8	-1.7	9	11	5	8	25	20	20	3
May	8.4	12.0	5.7	21.4	0.4	11	25	4	7	19	15	8	11
June	12.1	16.3	9.2	26.0	4.0	7	6	5	12	27	24	14	5
July	14.0	17.6	11.5	22.5	10.4	5	9	5	12	28	24	12	6
August	16.2	19.9	12.6	23.7	12.0	10	3	0	4	29	34	8	14
September	14.3	18.4	11.3	23.9	5.1	14	15	3	4	23	18	9	15
October	DATA UNAVAILABLE					DATA UNAVAILABLE							
November	2.0	4.5	-1.1	11.2	-10.1	21	11	5	1	7	7	23	25
December	-4.2	0.0	-8.3	14.2	-17.6	8	8	3	5	3	6	42	25
Annual	Mean 3.7	Mean 7.3	Mean 0.3	Extreme 26.0	Extreme -19.1	11	13	4	7	17	15	20	14
Years	1	1	1	1	1	1	1	1	1	1	1	1	1

*Each compass direction covers ± 22.5 degrees

Table 4.34: Meteorological Data for Point Lepreau (average 1986 to 1991)

Month	Temperature (Degrees Celsius)				Wind Direction* Relative % % Observation From								Relative % Pasquill Stability Classes						% UNAV		
	Avg	Mean Daily		Extreme	N	NE	E	SE	S	SW	W	NW	A	B	C	D	E	F		G	
		Max	Min	Max																	Min
January	-4.9	-0.8	-8.9	7.2	-25.3	11	10	4	5	10	19	18	23	19	9	8	26	22	12	5	3
February	-5.4	-1.8	-9.4	7.3	-21.9	16	8	3	4	11	22	15	23	22	11	11	23	19	9	5	1
March	-1.5	1.5	-4.7	13.5	-24.9	19	13	4	5	15	17	9	19	16	8	8	25	25	12	7	2
April	3.3	5.9	1.1	16.4	-4.2	20	25	6	6	17	13	8	5	12	5	7	25	33	12	6	15
May	7.9	11.2	5.5	25.6	-0.7	13	19	6	6	22	22	7	5	8	4	6	21	32	17	13	18
June	11.4	14.6	9.0	26.1	4.1	8	17	7	6	20	23	12	8	4	2	3	16	36	23	16	14
July	14.4	17.3	12.0	25.2	6.9	5	12	5	7	25	31	10	6	2	1	2	11	31	27	27	9
August	14.8	17.5	12.7	25.0	8.3	6	10	5	8	23	27	14	8	2	1	1	9	29	33	26	7
September	12.0	14.4	9.9	26.3	1.1	8	9	4	6	20	24	16	14	5	2	3	18	34	25	13	6
October	8.4	10.7	6.1	18.9	-1.7	13	10	7	9	19	18	14	11	5	4	5	27	30	17	12	3
November	2.8	5.7	-0.2	14.5	-13.7	13	9	4	7	11	13	22	23	9	5	8	34	25	15	4	1
December	-4.0	-0.1	-8.0	11.1	-21.1	13	6	5	3	7	13	25	28	18	11	11	27	21	9	3	5
Period	Mean 4.9	Mean 8.1	Mean 2.2	Mean 26.3	Extreme -25.3	12	12	5	6	17	20	14	15	10	5	6	22	28	18	11	7
Years	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

42 Metre Tower data

*Each compass direction covers ± 22.5 degrees

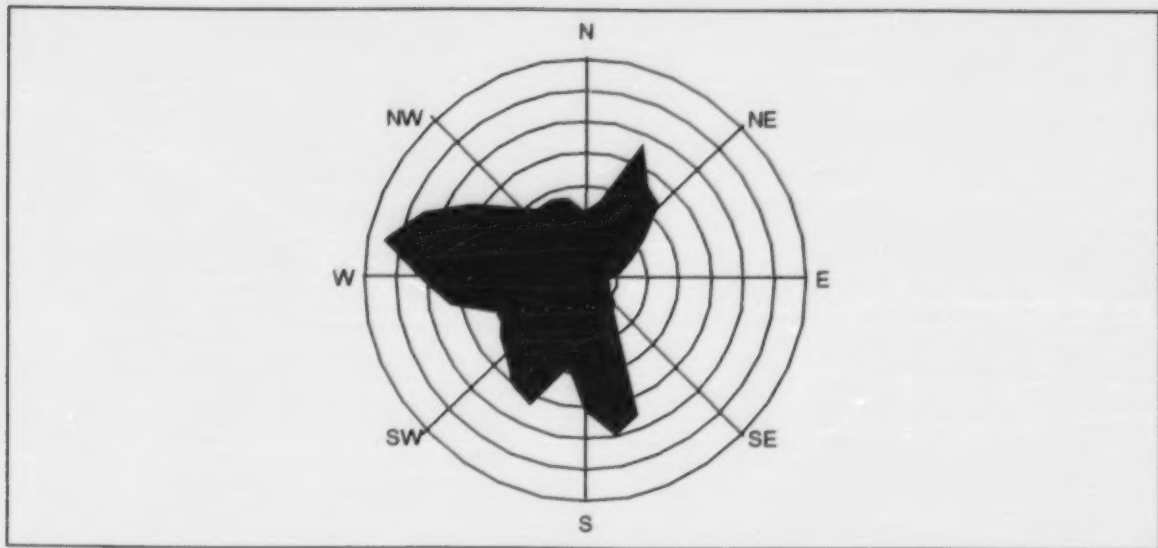


Figure 4.17: Wind Rose for Point Lepreau (2000)

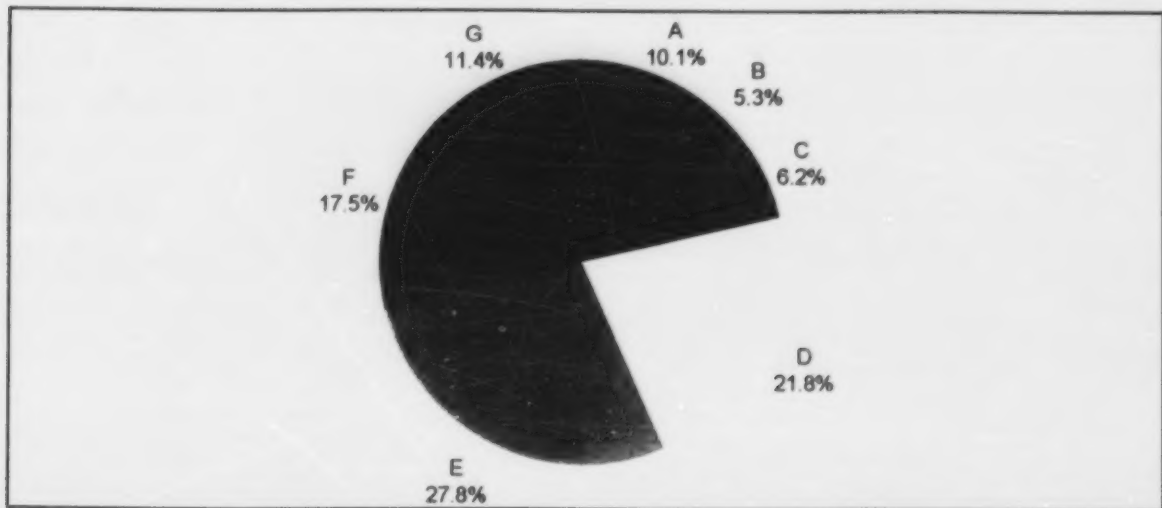


Figure 4.18: Pasquill Stability Factors For Point Lepreau (1986 to 1991)

5 Trends

The only trend that was obvious from the historical data, and continued in 2000, was increasing H-3 in Parshall Flume water from the SRWMF-Phase 1 (Figure 5.20).

As in the figures in Section 4, "Less Than" values are plotted for non-detected values. All location codes are described in Appendix C.

5.01 Dose from Airborne and Liquid Pathways

Radiation dose from PLGS emissions continues to be well below the public dose limit (1000 microsieverts per annum), and also well below the operating target for nuclear power facilities in Canada (50 microsieverts per annum).

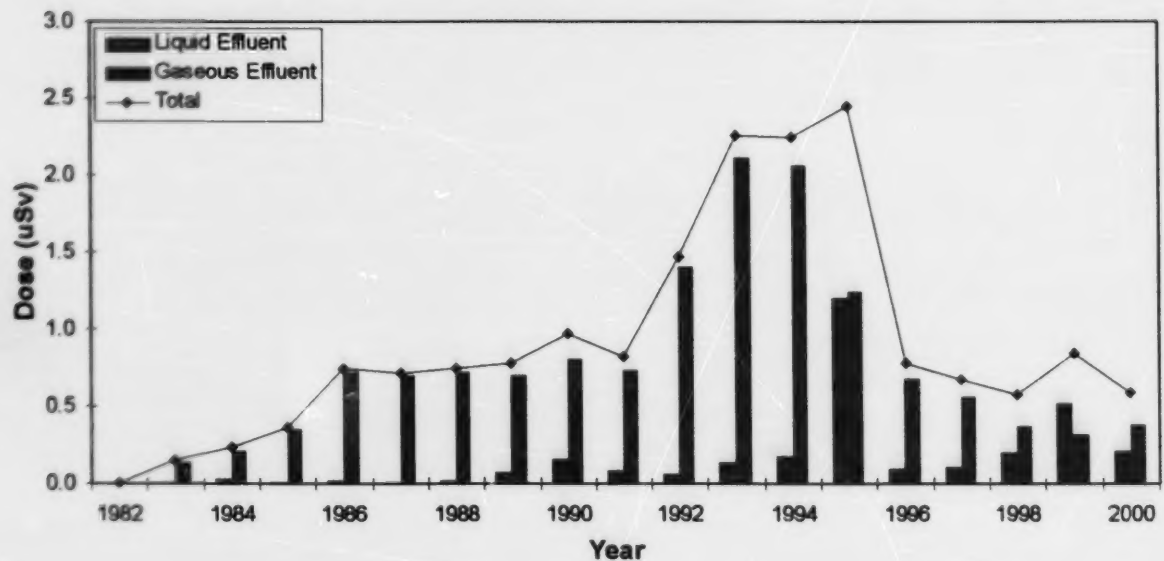


Figure 5.01: Dose from Airborne and Liquid Pathways

5.02 Gross Beta in Air

Figures 5.02 and 5.03 show the gross beta data for all air stations since the NB Power program began in 1976. A plot of the gross beta data from Dipper Harbour, about 4 km from the PLGS stack and in the predominant downwind direction, is presented in Figure 5.04. The baseline data show the naturally occurring radioactivity in the area. The peaks on the plots correspond to fallout from various atmospheric bomb tests which were most common in the 1950s and 1960s but decreased into the 1970s. Fallout from the Chinese atmospheric bomb test in October of 1980 (fallout occurred in 1981 in N.B.), and from the Chernobyl accident in April 1986, were obvious. Figure 5.05 shows a comparable plot of data from Health and Welfare Canada, but for the whole of Canada from 1959 (when data were first collected) to 1991. The scale is very much condensed to allow the bomb test fallout levels to be kept on-scale.

The Chernobyl accident released, in a period of a few days, about 1% as much radioactivity to the environment as all of the U.S. atmospheric bomb tests combined, released over several years.

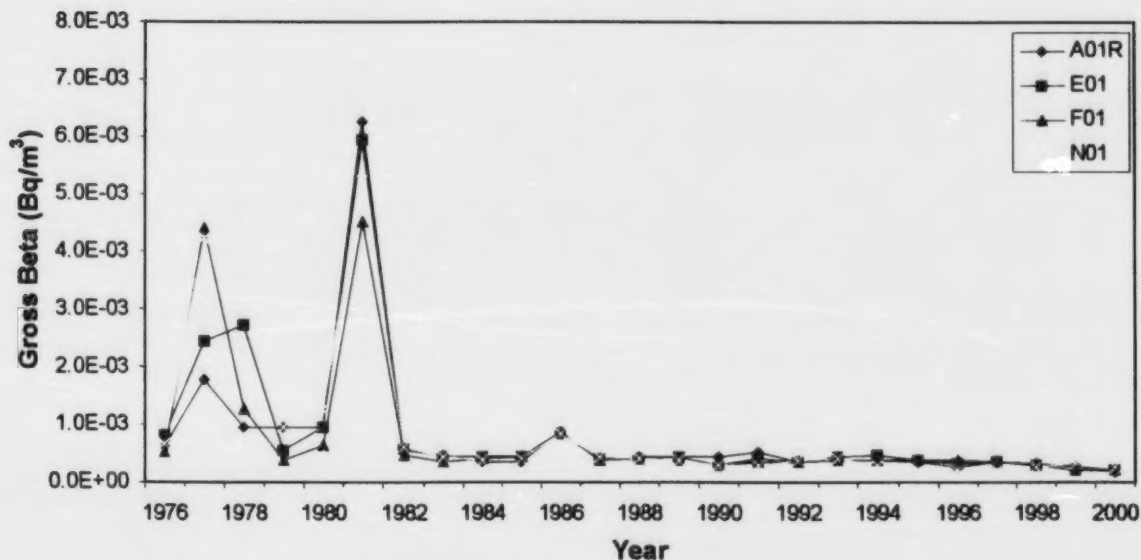


Figure 5.02: Gross Beta in Air (Offsite Air Stations)

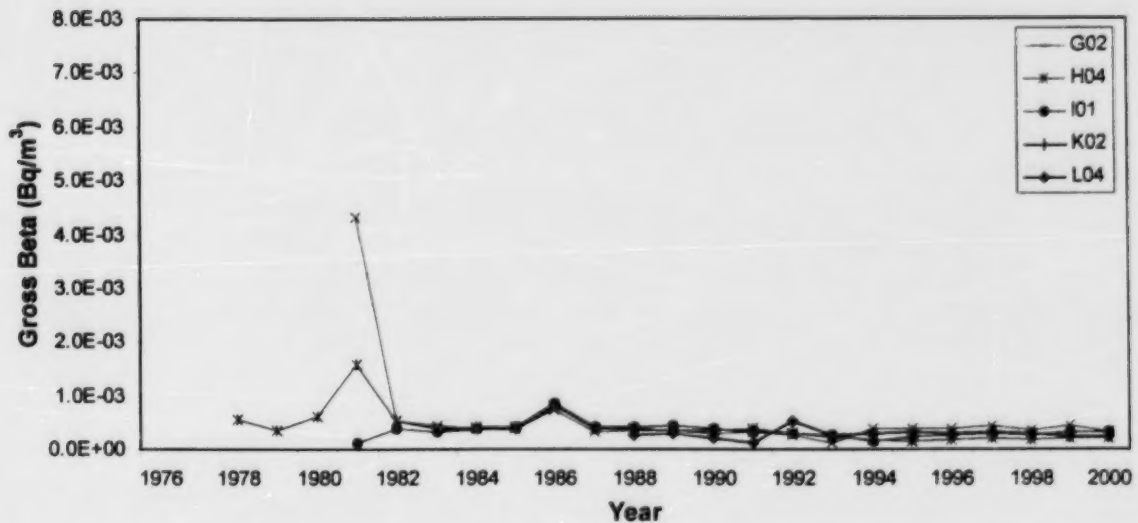


Figure 5.03: Gross Beta in Air (Onsite Air Stations)

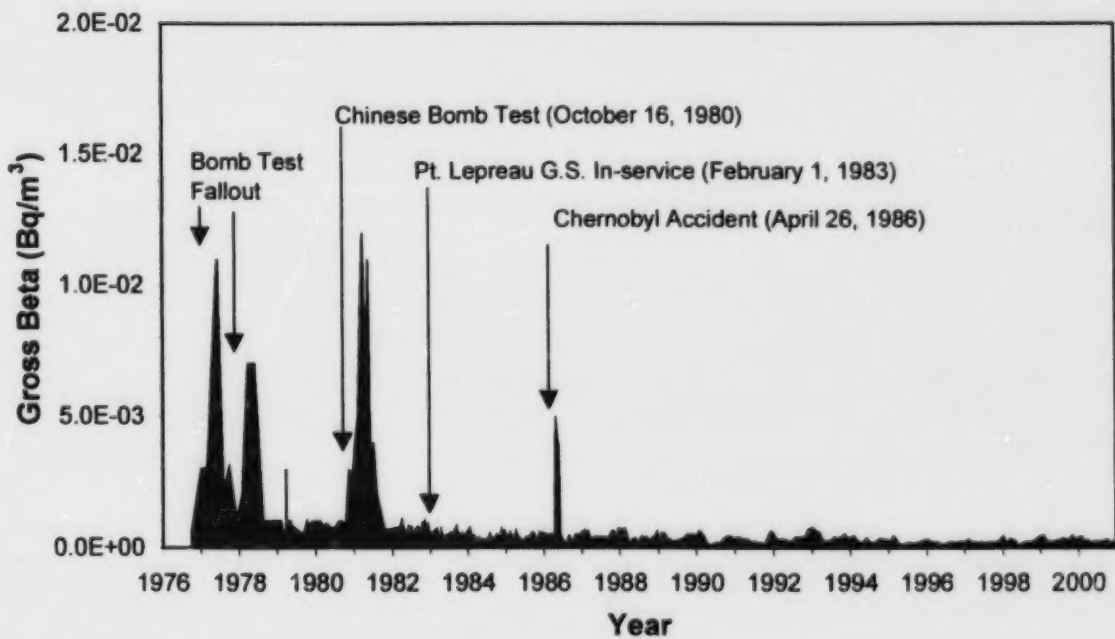


Figure 5.04: Gross Beta Activity in Air at Dipper Harbour

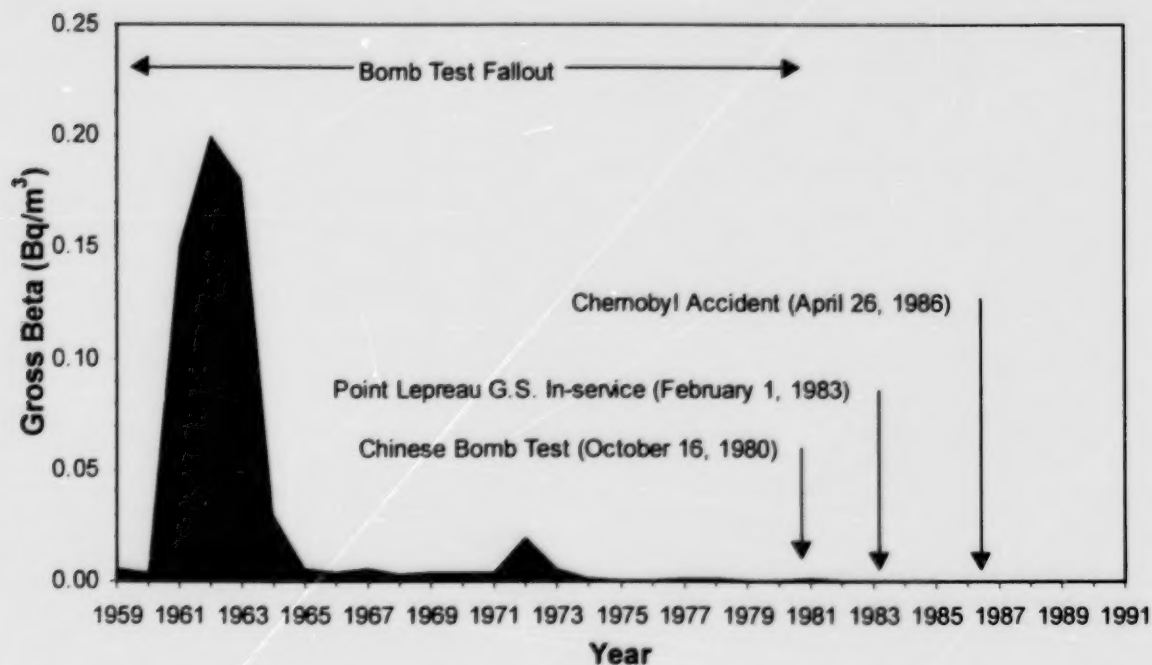


Figure 5.05: Annual Average Gross Beta Activity in Air for Canada 1959 to 1991 (Health and Welfare Canada Data)

5.03 Tritiated Water in Air

The onsite stations show a decline since the peak in 1993/1994, as have station airborne tritium emissions. See Figures 5.06 and 5.07.

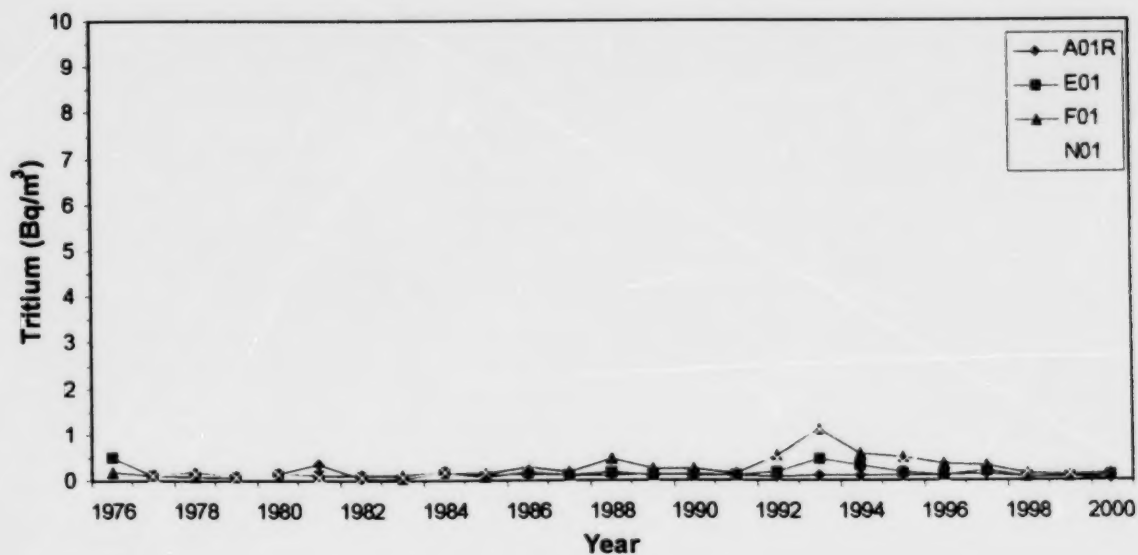


Figure 5.06: Tritiated Water in Air (Offsite)

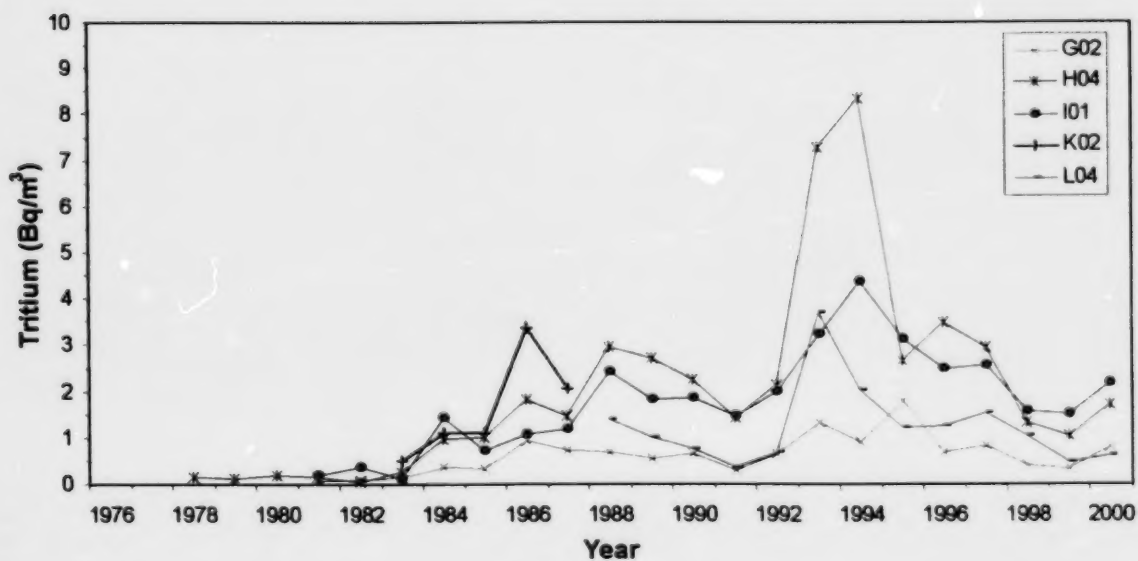


Figure 5.07: Tritiated Water in Air (Onsite)

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5.04 Atmospheric Dispersion Factors

The annual average dispersion factor for stack emissions up to this time is between $1\text{E-}7$ and $2\text{E-}7 \text{ s/m}^3$. This factor is based upon the data for H-3. A value of $2\text{E-}7$, based on such empirical data, is used in the DEL calculations. Results since 1984 are presented in Table 5.02.

In the calculation of the mean dispersion factor at each location, the average recorded is now the average of the detected values and the "Less Than" values. This will give a conservative estimate of the true value (i.e., less dispersion of the radionuclides).

To derive a normalised mean dispersion factor at 1 km from the stack for all locations, each dispersion factor value is corrected to 1 km. This is accomplished by tracing back between dispersion curves on the graph of "Weighted Mean Dilution Factor versus Distance from the Point of Continuous Emission"⁽⁹⁾. The average of these normalised values is presented in Table 5.01.

Table 5.01: Normalised Mean Dispersion Factor at 1 km for All Indicator Locations

<i>Year</i>	<i>Dispersion Factor (s/m³)</i>
1984	2E-07
1985	1E-07
1986	1E-07
1987	1E-07
1988	2E-07
1989	2E-07
1990	1E-07
1991	1E-07
1992	1E-07
1993	1E-07
1994	1E-07
1995	2E-07
1996	2E-07
1997	2E-07
1998	2E-07
1999	2E-07
2000	2E-07
Average over 17 years	<2E-07

Table 5.02: Average Atmospheric Dispersion Factor for Each Air Monitoring Location

Location Code	E01	F01	G02	H04	I01	K02	L04	N01
Location	Maces Bay	Welch Cove	Lepreau Lighthouse	Old Site of Information Centre	SRWMF	CCW Pumphouse	Construction Stores	Dipper Harbour
Distance from PLGS	4.5 km	1.6 km	1.0 km	0.75 km	1.2 km	0.2 km	0.55 km	3.7 km
Year	Release	Dispersion Factor (s/m ³)						
1984	6.8E13	8E-8	2E-7	5E-7	7E-7**	5E-7	-	8E-8
1985	1.1E14	2E-8	4E-8	3E-7	2E-7	3E-7	-	5E-8
1986	2.0E14	3E-8	5E-8	3E-7	2E-7	5E-7	-	6E-8
1987	2.2E14	2E-8	2E-8	2E-7	2E-7	3E-7	-	7E-8
1988	2.2E14	3E-8	7E-8	4E-7	3E-7	#	2E-7	9E-8
1989	2.1E14	2E-8	4E-8	4E-7	3E-7	#	2E-7	8E-8
1990	2.5E14	2E-8	3E-8	3E-7	2E-7	#	1E-7	8E-8
1991	1.7E14	2E-8	3E-8	3E-7	3E-7	#	7E-8	7E-8
1992	3.6E14	2E-8	5E-8	2E-7	2E-7	#	6E-8	4E-8
1993	6.4E14	2E-8	5E-8	4E-7	2E-7	#	2E-7	5E-8
1994	5.6E14	2E-8	3E-8	5E-7	2E-7	#	1E-7	1E-7
1995	3.1E14	2E-8	5E-8	3E-7	3E-7	#	1E-7	4E-8
1996	2.4E14	2E-8	5E-8	5E-7	3E-7	#	2E-7	8E-8
1997	2.1E14	3E-8	5E-8	4E-7	4E-7	#	2E-7	9E-8
1998	1.3E14	2E-8	3E-8	3E-7	4E-7	#	3E-7	5E-8
1999	9.5E13	7E-8	5E-8	3E-7	5E-7	#	1E-7	1E-7
2000	1.3E14	2E-8	3E-8	4E-7	5E-7	#	1E-7	8E-8

**This value includes a second source term: H-3 from containers temporarily located in this facility in 1984 and picked up by the air sampler (ignored in the calculation of the normalised mean dispersion factor).

No longer in use. This monitoring station was relocated to L04 - the Construction Stores Compound - in the spring of 1988.

5.04 Atmospheric Dispersion Factors

The annual average dispersion factor for stack emissions up to this time is between $1\text{E-}7$ and $2\text{E-}7 \text{ s/m}^3$. This factor is based upon the data for H-3. A value of $2\text{E-}7$, based on such empirical data, is used in the DEL calculations. Results since 1984 are presented in Table 5.02.

In the calculation of the mean dispersion factor at each location, the average recorded is now the average of the detected values and the "Less Than" values. This will give a conservative estimate of the true value (i.e., less dispersion of the radionuclides).

To derive a normalised mean dispersion factor at 1 km from the stack for all locations, each dispersion factor value is corrected to 1 km. This is accomplished by tracing back between dispersion curves on the graph of "Weighted Mean Dilution Factor versus Distance from the Point of Continuous Emission"⁽⁹⁾. The average of these normalised values is presented in Table 5.01.

Table 5.01: Normalised Mean Dispersion Factor at 1 km for All Indicator Locations

<i>Year</i>	<i>Dispersion Factor (s/m³)</i>
1984	2E-07
1985	1E-07
1986	1E-07
1987	1E-07
1988	2E-07
1989	2E-07
1990	1E-07
1991	1E-07
1992	1E-07
1993	1E-07
1994	1E-07
1995	2E-07
1996	2E-07
1997	2E-07
1998	2E-07
1999	2E-07
2000	2E-07
Average over 17 years	<2E-07

Table 5.02: Average Atmospheric Dispersion Factor for Each Air Monitoring Location

Location Code	E01	F01	G02	H04	I01	K02	L04	N01
Location	Maces Bay	Welch Cove	Lepreau Lighthouse	Old Site of Information Centre	SRWMF	CCW Pumphouse	Construction Stores	Dipper Harbour
Distance from PLGS	4.5 km	1.6 km	1.0 km	0.75 km	1.2 km	0.2 km	0.55 km	3.7 km
Year	Release	Dispersion Factor (s/m ³)						
1984	6.8E13	8E-8	2E-7	5E-7	7E-7**	5E-7	-	8E-8
1985	1.1E14	4E-8	9E-8	3E-7	2E-7	3E-7	-	5E-8
1986	2.0E14	5E-8	1E-7	3E-7	2E-7	5E-7	-	6E-8
1987	2.2E14	2E-8	1E-7	2E-7	2E-7	3E-7	-	7E-8
1988	2.2E14	7E-8	1E-7	4E-7	3E-7	#	2E-7	9E-8
1989	2.1E14	4E-8	8E-8	4E-7	3E-7	#	2E-7	8E-8
1990	2.5E14	2E-8	8E-8	3E-7	2E-7	#	1E-7	8E-8
1991	1.7E14	2E-8	5E-8	3E-7	3E-7	#	7E-8	7E-8
1992	3.6E14	5E-8	5E-8	2E-7	2E-7	#	6E-8	4E-8
1993	6.4E14	5E-8	6E-8	4E-7	2E-7	#	2E-7	5E-8
1994	5.6E14	3E-8	5E-8	5E-7	2E-7	#	1E-7	1E-7
1995	3.1E14	5E-8	2E-7	3E-7	3E-7	#	1E-7	4E-8
1996	2.4E14	5E-8	9E-8	5E-7	3E-7	#	2E-7	8E-8
1997	2.1E14	5E-8	1E-7	4E-7	4E-7	#	2E-7	9E-8
1998	1.3E14	3E-8	1E-7	3E-7	4E-7	#	3E-7	5E-8
1999	9.5E13	5E-8	1E-7	3E-7	5E-7	#	1E-7	1E-7
2000	1.3E14	3E-8	2E-7	4E-7	5E-7	#	1E-7	8E-8

**This value includes a second source term: H-3 from containers temporarily located in this facility in 1984 and picked up by the air sampler (ignored in the calculation of the normalised mean dispersion factor).

No longer in use. This monitoring station was relocated to L04 - the Construction Stores Compound - in the spring of 1988.

5.05 Strontium-90 in Air (GEM)

There have only been a few years when Sr-90 was detected in station effluents. The maximum values for Sr-90 still represent only a small fraction of the DEL and are due to activity detected just above the detection limit.

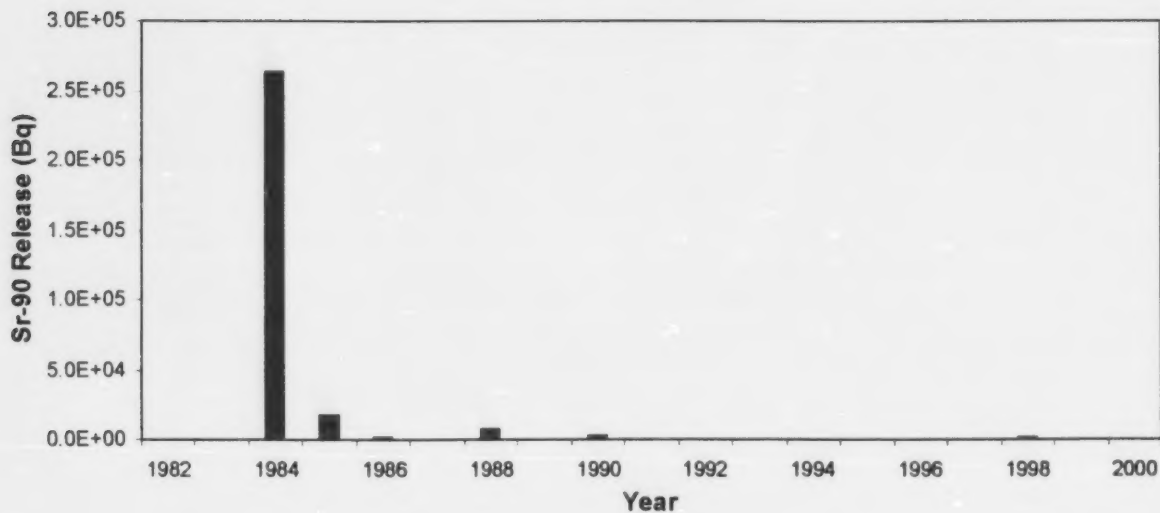


Figure 5.08: Sr-90 in Air (GEM)

5.06 TLD Measurements

A plot of summary TLD data since 1978 is presented in Figure 5.09. There is only one reference location (A01R in Bocabec) while the other groups are the average of many locations. *Boundary* refers to locations at the edge of NB Power property.

The variation in natural background radiation at any individual location covers a range of about 300 microgray from year to year. A few locations (close to the reactor building and the air emissions stack) show significant, but small, increases in gamma radiation due to chronic releases of low levels of noble gases. In 1995, the extended outage resulted in fewer noble gas emissions and thus lower dose measured by these TLDs. Small increases at the SRWMF are due to low-level waste and used fuel emplacement and not to station emissions.

Background radiation in any of the monitored residential areas has not increased from the levels measured before the Point Lepreau Generating Station was placed into operation.

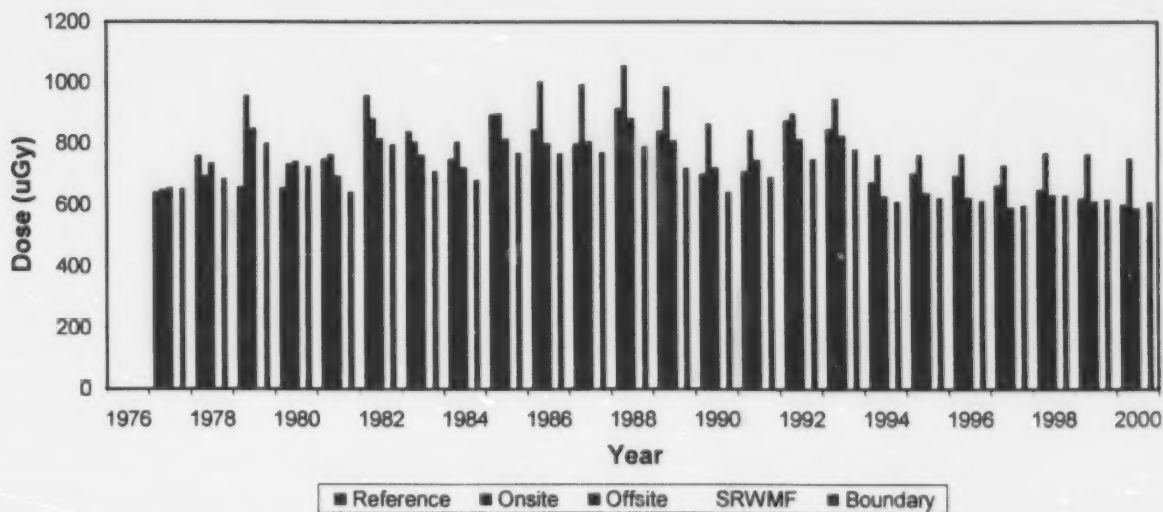


Figure 5.09: TLD Measurements

5.07 Gross Beta in Well Water

The beta activity is due to the presence of naturally occurring radionuclides (especially radon progeny). As expected, there has been no significant change in this parameter over the years.

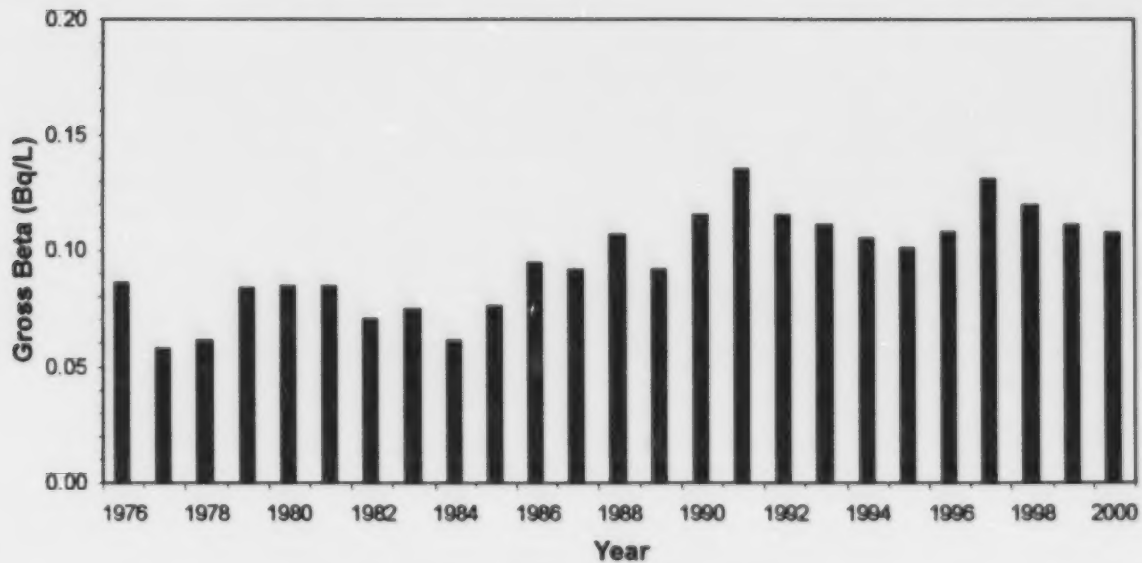


Figure 5.10: Gross Beta in Well Water

5.08 Tritium in Well Water

Precipitation and surface water contain tritium from PLGS emissions. Even though there is surface runoff into some shallow wells, there has been no significant change in this parameter over the years.

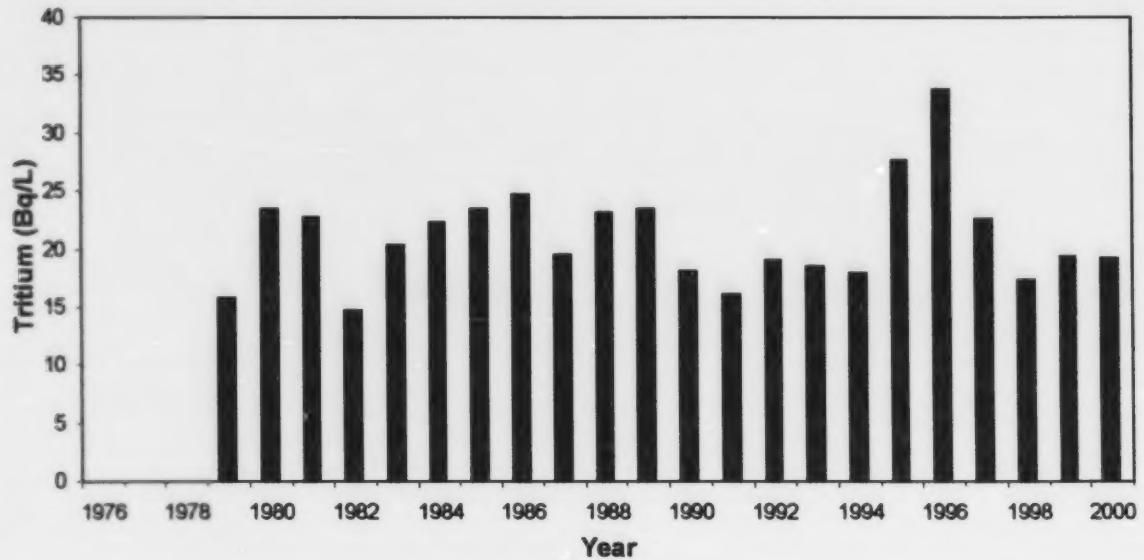


Figure 5.11: Tritium in Well Water

5.09 Cs-137 in Soil

Cesium-137 from fallout from past atmospheric bomb tests tends to accumulate in the organic layer of the soil. Any fluctuation seems to be due to this organic load in the sample. There were no soil samples from 1986 to 1992 because at the time, this fluctuation caused it to be viewed as an unimportant sample type.

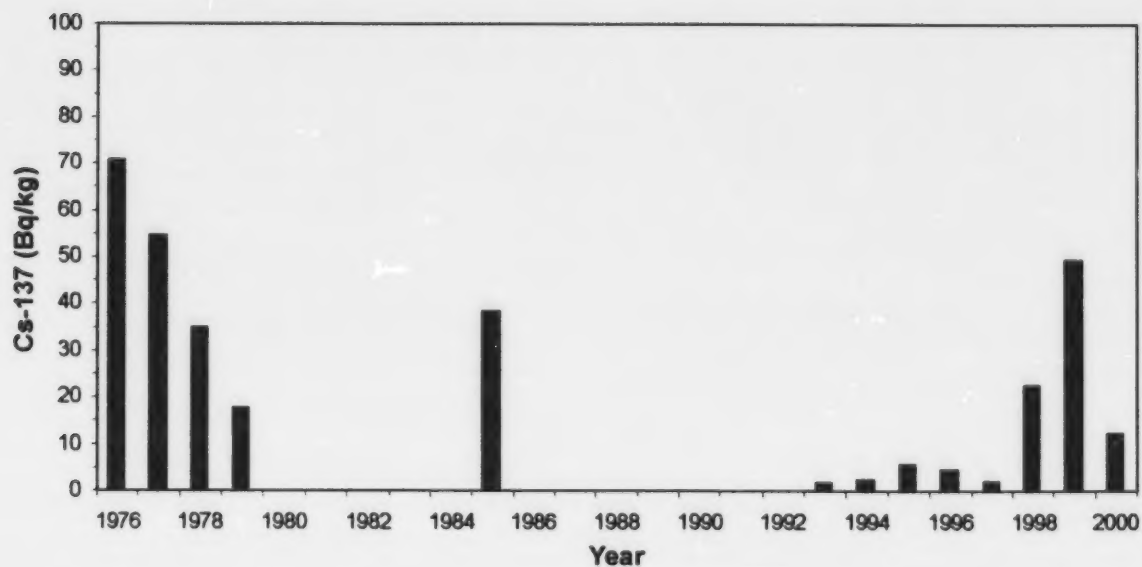


Figure 5.12: Cs-137 in Soil

5.10 Cs-137 in Sediment

The effects of the atmospheric bomb tests and the accident at Chernobyl continue to be seen here. There has been no significant change in this parameter over the years.

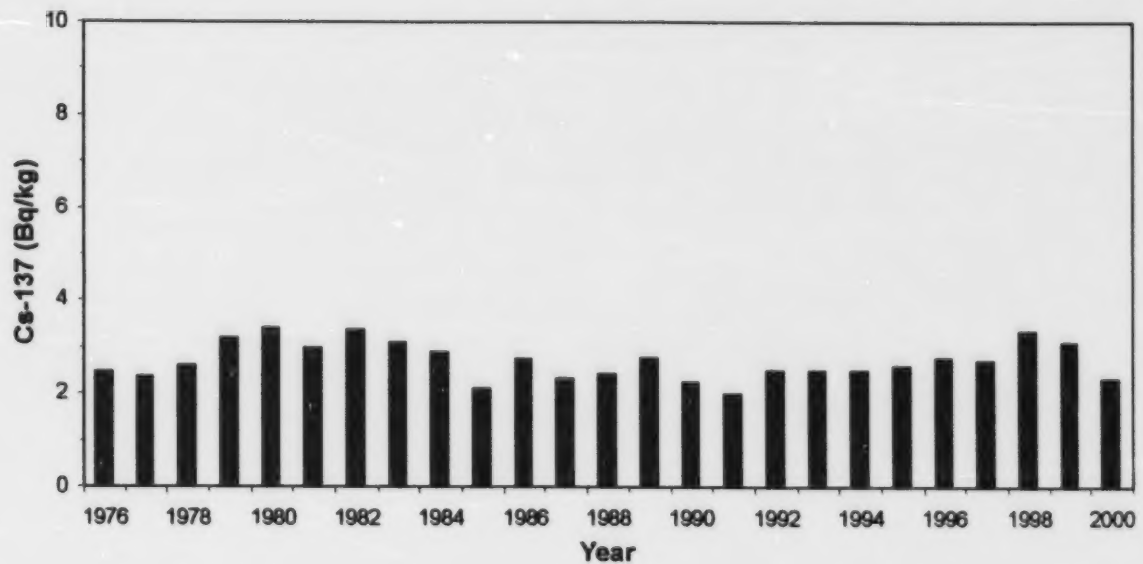


Figure 5.13: Cs-137 in Sediment

5.11 Tritium in Seawater

The increase in H-3 in 1996 and 1997 were due to samples being taken directly over the outfall. These samples are usually taken at the shore, where the effects of tidal mixing are evident.

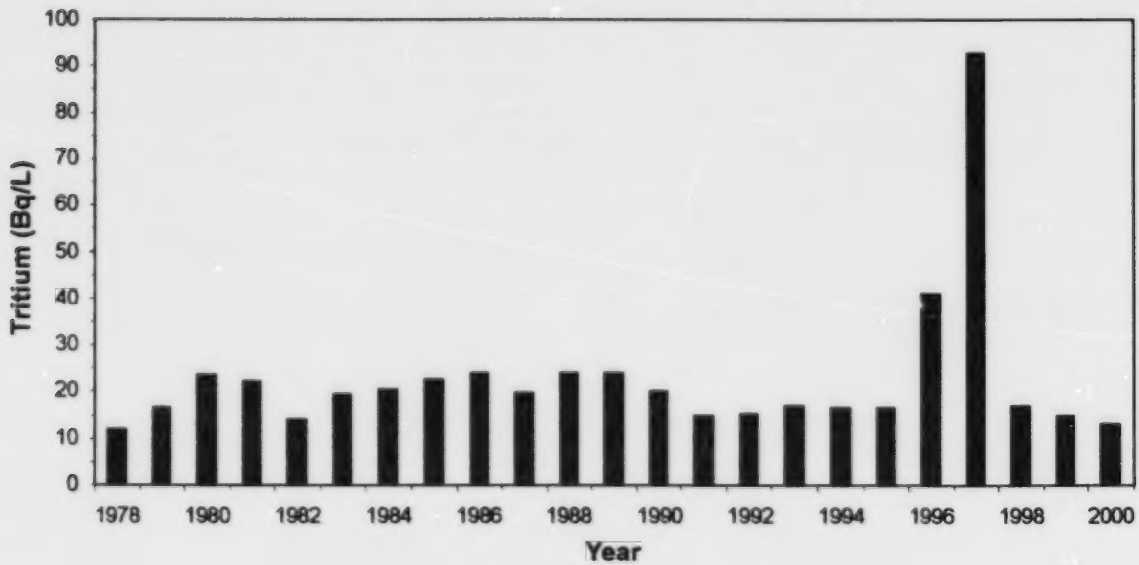


Figure 5.14: Tritium in Seawater

5.12 Strontium-90 in LEM

The maximum values for Sr-90 still represent only a small fraction of the DEL and are due to activity detected just above the detection limit.

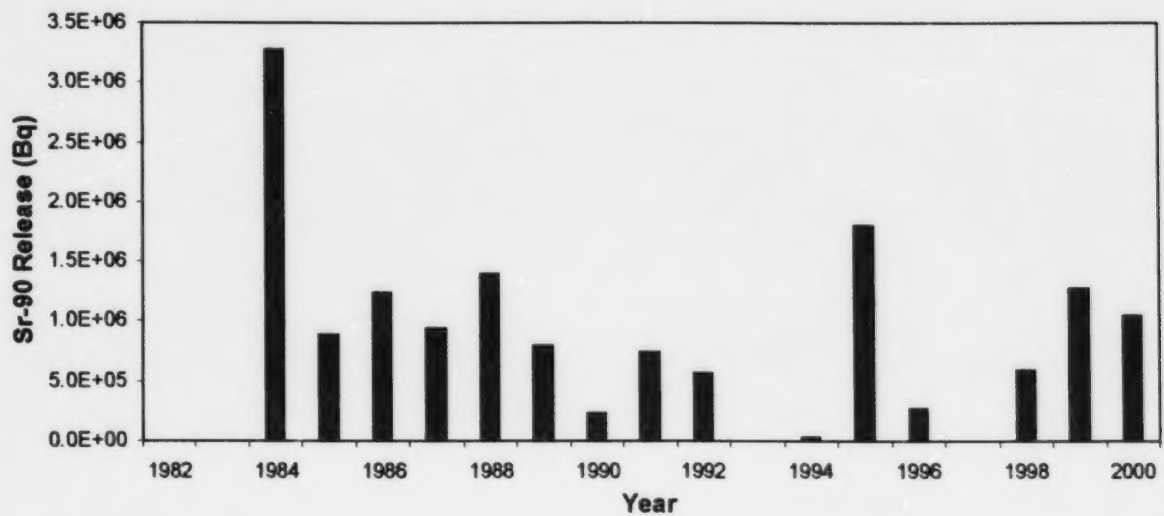


Figure 5.15: Sr-90 in LEM

5.13 Tritium in Bore Holes and Parshall Flumes

The values at Phase 2 are typically less than those at Phase 1, indicating possible dilution of the surface runoff to the flume or a developing problem with the Phase 1 structures. There has been a general upward trend in the Phase 1 Parshall Flume and bore hole results since the late 1980s.

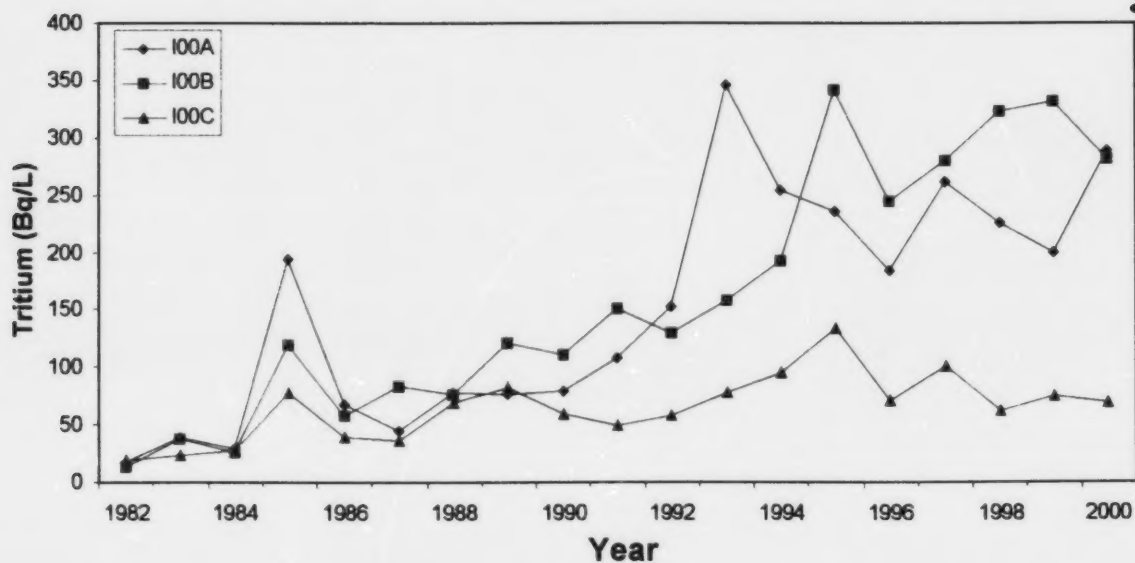


Figure 5.16: H-3 in Bore Holes

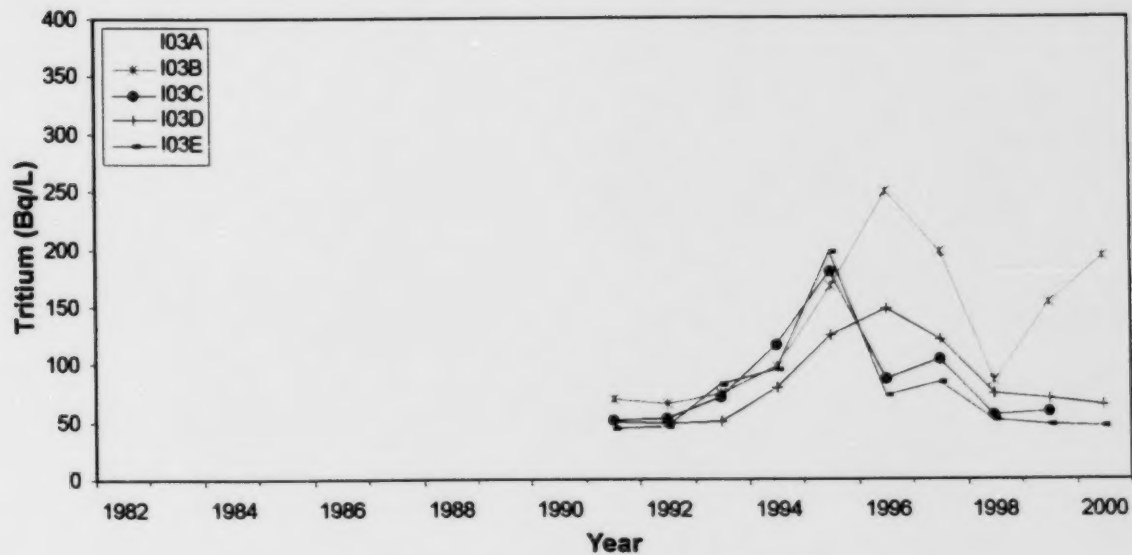


Figure 5.17: H-3 in Bore Holes

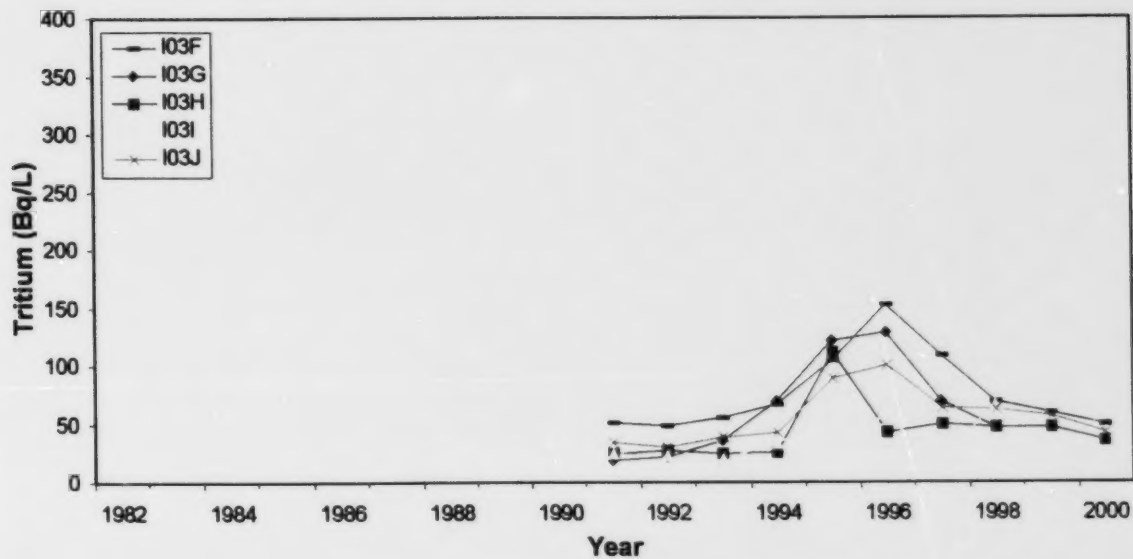


Figure 5.18: H-3 in Bore Holes

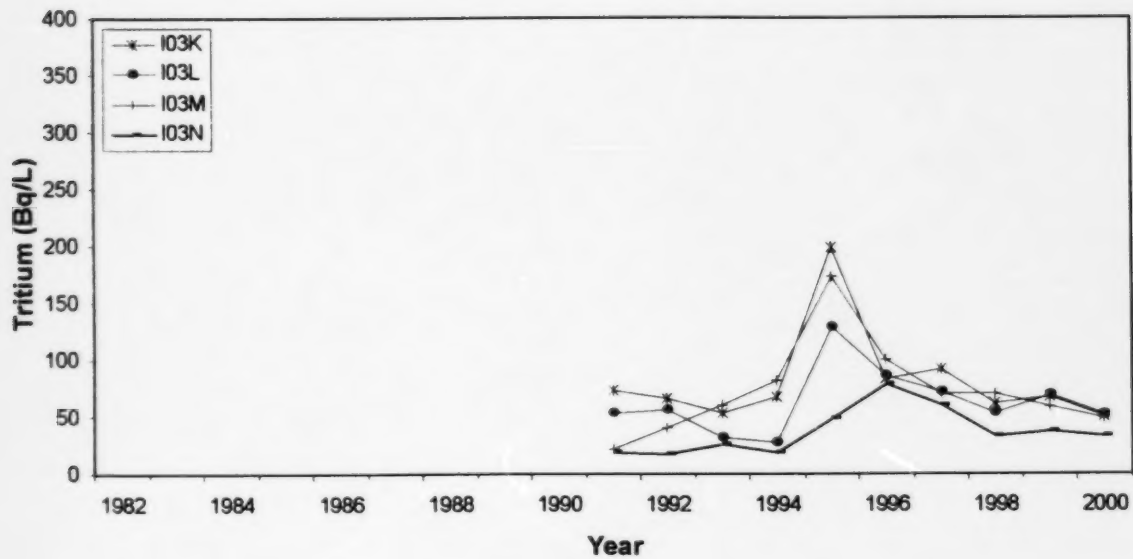


Figure 5.19: H-3 in Bore Holes

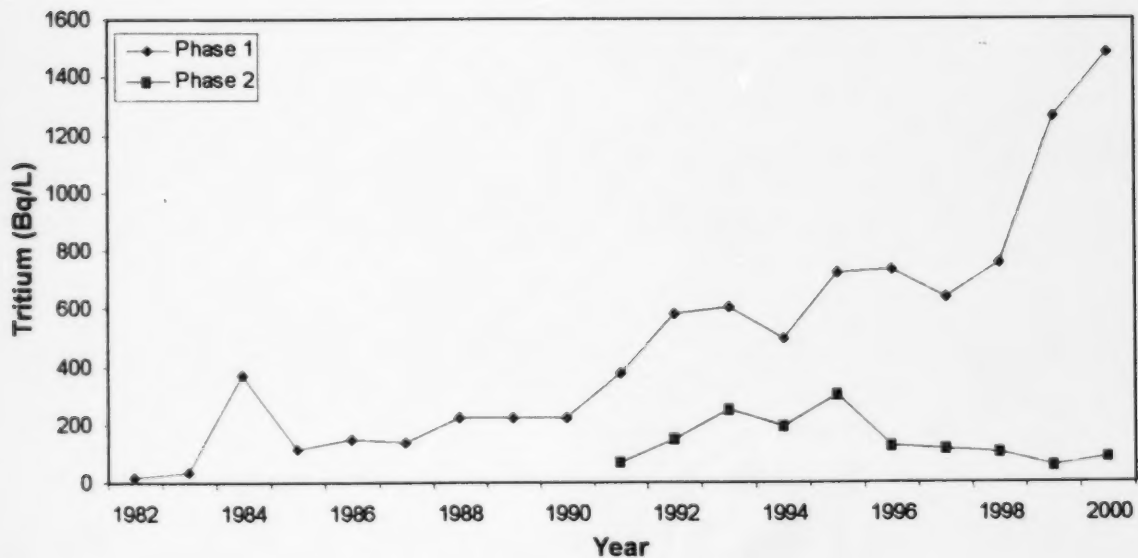


Figure 5.20: H-3 in Parshall Flumes

5.14 Drop Off TLDs

Dosimeters are in place in two directions from the boundary fence of the SRWMF - Phase 2 facility to measure drop-off of radiation from the filled dry fuel storage canisters with distance, to about 200 metres. Results are presented in Figure 5.21. Each point on the graph is the average for all the years the facility has operated. The B direction is higher than the A direction because the rocky terrain has a higher natural background.

The bar charts in Figure 5.22 and Figure 5.23 present the annual dose for each location (since 1991).

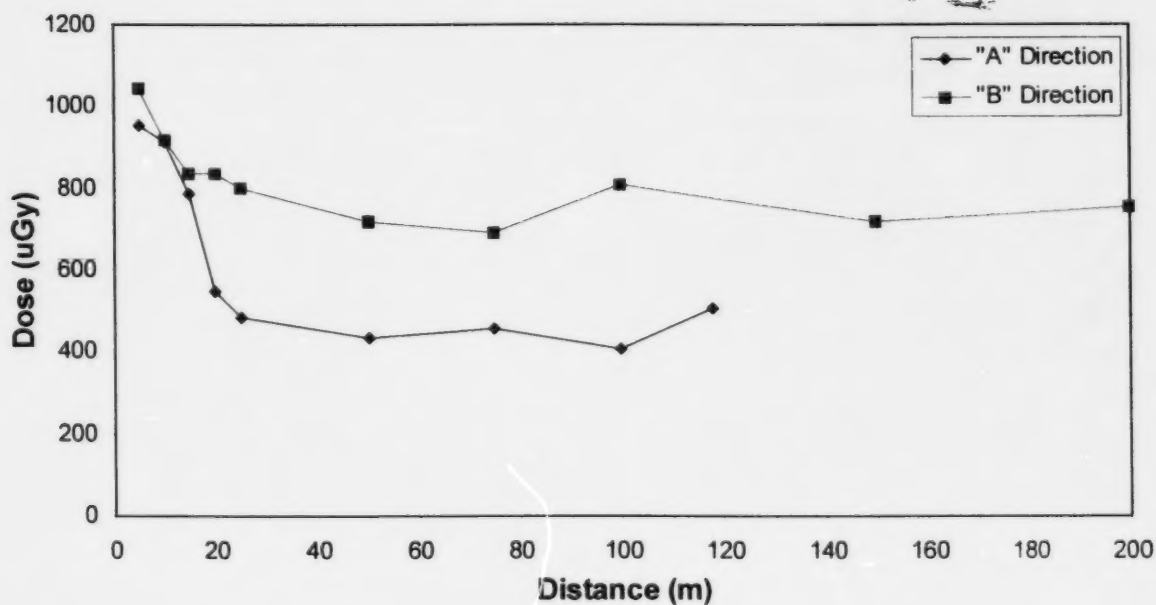


Figure 5.21: Drop off TLDs

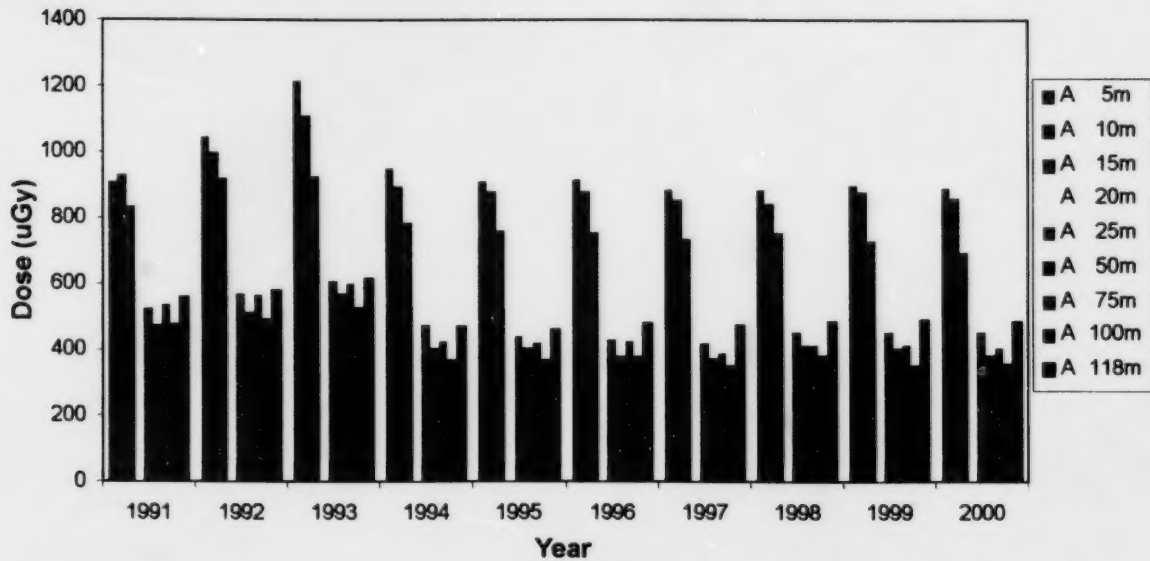


Figure 5.22: Drop off TLDs

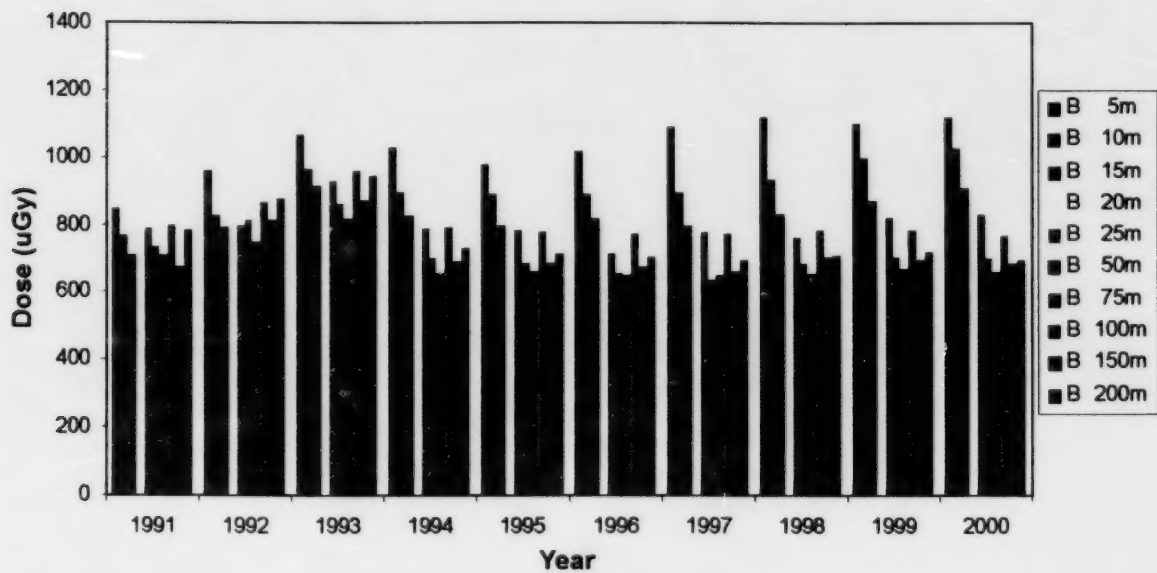


Figure 5.23: Drop off TLDs

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6 Dose Estimation

Based upon the total percent DEL for all monitored radionuclides in each pathway for 2000, the calculated annual whole body radiation dose to members of the Critical Groups was about 0.2 μSv from liquid emissions and about 0.4 μSv from airborne emissions. This latter calculation allows for the actual location of an existing dairy herd in 2000 at about 40 km, rather than assuming the existence of a hypothetical herd at 1.5 km. This results in a dose reduction factor of about 12 for C-14 in the milk pathway because of the differences in dispersion factors between 1.5 km and 40 km ($6\text{E-}08 \text{ s/m}^3$, and $5\text{E-}09 \text{ s/m}^3$, respectively).

Because of the protective assumptions used in the DEL calculations, and the relatively low level of emissions, the most exposed member of the general public received far less than the calculated dose. This radiation dose may be compared with the individual natural radiation dose in the Point Lepreau area of approximately 2000 to 3000 μSv per annum. (TLDs show only the external, penetrating component, amounting to about 500 to 1000 μSv .) This includes natural dose contributions from ground, air, food and from an assumed low concentration of radon in homes. A significant fraction of Canadian homes contain radon levels that give a radiation dose much larger than this. In addition, the average annual medical radiation dose is about 350 μSv per person.

Table 6.01: Annual Dose

<i>Source of Dose to Critical Group</i>	<i>Dose to Critical Group ($\mu\text{Sv/a}$)</i>
PLGS airborne emissions	0.38
PLGS liquid emissions	0.21
natural background (estimate)	2 000
average medical dose (estimate)	350

The only assessable radiation dose from PLGS on the local population is that from tritiated water vapour in air. This continues to be detected offsite in air and water samples.



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7 Quality Assurance Results

The purpose of Quality Assurance is to provide confidence in the program and demonstrate that the program is able to meet its objectives. QA consists of the system whereby the laboratory can assure the regulator, NB Power, and the public that the laboratory is generating data of proven and known quality. It encompasses:

- personnel
- procedures
- measurements
- contamination
- records
- annual review
- program audits
- program improvement

This section describes how this was achieved for the year 2000. The specific procedures can be found in the *Quality Assurance* section of *Environmental Radiation Monitoring Program Procedures*⁽¹¹⁾.

There was an improvement in the QA program over 1999 with the re-establishment of an external cross check program. Several suppliers were identified and much of the year was spent ramping up this aspect of the program to the desired level.

7.01 Daily Quality Control

At the beginning of each day, the four main pieces of analytical equipment have a quality control check performed on them. Key instrument parameters are checked and the results are compared against tolerance limits, and are also compared with previous results to detect trends in performance. To perform the quality control checks, radiation sources traceable to US or Canadian standards (NIST and National Research Council) are used. Failures are investigated immediately.

The daily Quality Control (QC) evaluations in the laboratory cover the following instruments:

1. Canberra Intrinsic Ge Gamma Spectrometer
2. Beckman Liquid Scintillation Counter
3. Tennelec LB-5100 Gross Alpha/Beta Detector
4. Panasonic UD-710A TLD Reader

In the QC program, the operating parameters of each of the major instruments are evaluated at the start of each working day. This ensures that they are consistent and remain free from significant

drift or random variation that could influence the analyses. A compilation of the results and statistical fluctuations is maintained, and from these data the upper and lower flag limits are determined. If any equipment exceeds these limits, it is not used for any analytical work until the problem has been resolved.

Throughout the year there were failures for each of the instruments. These failures involved only one of the seven to ten parameters monitored for each system. All of these failures were minor and were resolved on the same day they occurred. Over the year, there was observed a downward trend in the unquenched H-3 standard efficiency for the LS system. This set of standards will be replaced in 2001.

Table 7.01: Daily QC Passes & Failures

<i>Instrument</i>	<i>Number of Parameters Monitored</i>	<i>Runs</i>	<i>Passes</i>	<i>Failures</i>	<i>Unresolved Failures</i>
Canberra Intrinsic Ge Gamma Spectrometer	7	248	241	7	0
Canberra Intrinsic Ge Gamma Spectrometer (Weekend Long Background)	8	51	50	1	0
Beckman Liquid Scintillation Counter	10	250	249	1	0
Tennelec LB-5100 Gross Alpha/Beta Detector	8	278	260	18	0
Panasonic UD-710A TLD Reader	8	257	244	13	0

7.01.01 Intrinsic Ge Gamma Spectrometer

A daily check of seven system parameters is performed for the germanium gamma spectroscopy system. Measurements are made of the energy centroids, full width half maxima (FWHM) and efficiencies of two widely separated photon energies of Eu-152. These show the accuracy and precision of the system relative to the defined limits of acceptance. The rate of liquid nitrogen consumption is monitored to verify the physical integrity of the cryostat. The results are processed by a computer program that generates QC plots and performs statistical tests to detect out-of-range values. A 200 000 s background count is made each weekend to ensure the absence of contamination in the sample chamber. The total counts in eight separate regions of the background spectrum are evaluated by the QC program, and out-of-range values are flagged for assessment.

The efficiency calibration of the gamma spectroscopy system is checked annually for each of the counting geometries. This is accomplished using a mixed nuclide standard traceable to the U.S. National Institute of Standards and Technology (NIST).

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The efficiency calibration of the gamma spectroscopy system is checked annually for each of the counting geometries. This is accomplished using a mixed nuclide standard traceable to the U.S. National Institute of Standards and Technology (NIST).

7.01.02 Beckman Liquid Scintillation Counter (model LS6000 TA)

A set of sealed tritium, C-14 and background standards traceable to NIST is analysed daily. Statistical parameters must lie within defined limits or the equipment will not be used. These same standards are used to calibrate the instrument for each analysis run.

7.01.03 Tennelec LB-5100 Gross Alpha/Beta Detector

Planchet standards of Am-241 and Sr,Y-90 are analysed daily. Alpha and Beta discrimination allows the simultaneous analysis of alpha and beta emissions on all samples analysed. Planchet and filter backgrounds are included in the QC checks. These same standards are used to calibrate the instrument for each analysis run.

7.01.04 Panasonic UD-710A TLD Reader

A set of 16 TLDs is exposed in the Panarad Irradiator and read out in the TLD reader. The mean of each of the four elements, dark current, reference light, reference element, and lamp flashes must all be within specified limits. The QA aspect of this system is covered in detail in *External Beta/Gamma Dosimetry Program*⁽¹⁰⁾.

7.01.05 Other Instruments

Other instruments (balances, pipettes) are checked or calibrated at least annually. See the *Calibration, Maintenance and Repair* section of *Environmental Radiation Monitoring Program Procedures*⁽¹¹⁾. Frequencies of calibration are based on reproducibility of measurements and on time stability tests to ensure that the measurements made are within the specified tolerances for accuracy.

The gamma survey meters and contamination monitor are calibrated at PLGS on an annual basis.

7.02 External QA

The external quality assurance program consists of inter-comparisons with other laboratories, to give independent verification of analytical performance. The frequency of each program may vary at the discretion of the sponsoring agency (see Table 7.02). Three such groups – the IAEA (International Atomic Energy Agency), USDOE (United States Department of Energy), and NTS (Nuclear Technology Services) provide up to 5% of the sample load in the laboratory with blind or semi-blind samples. Results of our performance with these samples gives an indication of the quality of measurements we are capable of producing.

Much of the year was spent identifying suppliers and overcoming difficulties in obtaining their samples. By year's end, the program was positioned to provide the quantity of samples necessary to fulfil program requirements.

The results are tabulated in Tables 7.03 to 7.14 and presented graphically in Figures 7.01 to 7.19.

Acceptable performance is defined by the QA agent, generally in terms of an expected range. A failure signals the need to assess the procedures, analytical methods, or equipment calibrations.

There were 3 failures in the external QA program in 2000. These included a high H-3 result reported in a USDOE water sample, a low Sr-89 result in an NTS water sample and a high K-40 result in an IAEA sediment. The H-3 failure was the result of interference from gamma (and beta) emitting radionuclides in the sample. As part of the investigation a portion of the original sample was distilled and the results from the analysis of the distillate matched those of the QA agent. The Sr-89 low result was due to excessive decay of the Sr-89 and uncertainties in the percent Sr-89 and Sr-90 in the mixture. We have been unable to resolve the reason for the high K-40 results in an IAEA sediment. The Cs-137 analysis on the sediment matched the IAEA result, so sample size and geometry effects have been ruled out as causes. Remaining possibilities are trace amounts of K-40 in the sample container (liquid scintillation vial) or in the filler (talc), which, when scaled up using the mass of sample in the container resulted in a large over-estimation of the activity present.

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Table 7.02: External Quality Assurance Frequency

<i>Media</i>	<i>Analyses</i>	<i>Number of QA Samples per Year</i>	<i>External Agencies</i>
Filters	Gross Alpha/Beta	2	USDOE
		4	NTS
	Gamma	2	USDOE
		4	NTS
	Sr-89,90	2	USDOE
		4	NTS
Environmental Gamma	TLD	2	NRC
		10 (every 3-4 y)	USDOE
Milk	Gamma	2	IAEA
Soil/Sediment	Gamma	2	USDOE
		1	IAEA
Water	Gross Alpha/Beta	2	USDOE
		4	NTS
	H-3	2	USDOE
		4	NTS
	C-14	4	NTS
	Gamma	2	USDOE
		4	NTS
	Sr-89,90	2	USDOE
		4	NTS
Charcoal Cartridges	Gamma	6	NTS
Food	Gamma	2	USDOE
		4	NTS
		2	IAEA
Urine	H-3	3	RPB
	C-14	3	RPB
	Gamma	1	RPB

Table 7.03: Comparison of QA Agent, All Participants and NB Power

Analysis	Agent	Table No.	Sample Date	NB Power/Agent	*All Participants
ALPHA	NTS	7.04	2000/05/15	0.99	0.00 - 0.00
		7.06	2000/05/15	1.08	0.00 - 0.00
	USDOE	7.08	2000/09/01	0.85	0.85 - 1.14
		7.10	2000/09/01	1.02	0.88 - 1.23
BETA	NTS	7.04	2000/05/15	0.89	0.00 - 0.00
		7.06	2000/05/15	1.08	0.00 - 0.00
	USDOE	7.08	2000/09/01	1.03	0.87 - 1.18
		7.10	2000/09/01	1.12	0.86 - 1.16
Ba-133	RPB	7.09	2000/10/03	1.54	0.91 - 1.27
Ba-133 r	RPB	7.09	2000/10/03	1.04	0.91 - 1.27
C-14	NTS	7.06	2000/05/15	0.84	0.00 - 0.00
C-14 #1	RPB	7.09	2000/05/25	0.94	0.89 - 1.03
C-14 #2	RPB	7.09	2000/05/25	0.95	0.88 - 1.13
C-14 #3	RPB	7.09	2000/05/25	0.91	0.85 - 1.10
Cd-109	NTS	7.04	2000/05/15	0.98	0.00 - 0.00
		7.06	2000/05/15	1.04	0.00 - 0.00
		7.05	2000/05/15	1.15	0.00 - 0.00
		7.07	2000/05/15	0.86	0.00 - 0.00
Ce-139	NTS	7.04	2000/05/15	1.02	0.00 - 0.00
		7.06	2000/05/15	1.07	0.00 - 0.00
		7.07	2000/05/15	0.87	0.00 - 0.00
Co-57	NTS	7.04	2000/05/15	1.04	0.00 - 0.00
		7.06	2000/05/15	0.98	0.00 - 0.00
		7.07	2000/05/15	0.83	0.00 - 0.00
	RPB	7.09	2000/10/03	1.09	0.90 - 1.11
Co-57 r	USDOE	7.10	2000/09/01	0.89	0.93 - 1.13
	RPB	7.09	2000/10/03	0.79	0.90 - 1.11
Co-60	NTS	7.04	2000/05/15	1.05	0.00 - 0.00
		7.06	2000/05/15	1.08	0.00 - 0.00
		7.05	2000/05/15	1.12	0.00 - 0.00
		7.07	2000/05/15	0.87	0.00 - 0.00
	RPB	7.09	2000/10/03	1.24	0.92 - 1.11
		7.08	2000/09/01	0.95	0.94 - 1.03
	USDOE	7.10	2000/09/01	0.97	0.96 - 1.10
Co-60 r	RPB	7.12	2000/09/01	1.04	0.93 - 1.16
		7.09	2000/10/03	0.95	0.92 - 1.11
		7.06	2000/05/15	1.17	0.00 - 0.00
		7.07	2000/05/15	0.75	0.00 - 0.00
Cs-137	RPB	7.09	2000/10/03	1.26	0.89 - 1.10
		7.08	2000/09/01	0.94	0.93 - 1.05
	USDOE	7.10	2000/09/01	1.05	0.99 - 1.16
		7.11	2000/09/01	0.88	0.95 - 1.12
		7.12	2000/09/01	1.11	0.94 - 1.13
		7.09	2000/10/03	0.93	0.89 - 1.10

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	Gamma	2	USDOE
		4	NTS
	Sr-89,90	2	USDOE
		4	NTS
Environmental Gamma	TLD	2	NRC
		10 (every 3-4 y)	USDOE
Milk	Gamma	2	IAEA
Soil/Sediment	Gamma	2	USDOE
		1	IAEA
Water	Gross Alpha/Beta	2	USDOE
		4	NTS
	H-3	2	USDOE
		4	NTS
	C-14	4	NTS
		4	NTS
	Gamma	2	USDOE
		4	NTS
	Sr-89,90	2	USDOE
		4	NTS
Charcoal Cartridges	Gamma	6	NTS
Food	Gamma	2	USDOE
		4	NTS
		2	IAEA
Urine	H-3	3	RPB
	C-14	3	RPB
	Gamma	1	RPB

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		7.10	2000/09/01	1.02	0.88 - 1.23
BETA	NTS	7.04	2000/05/15	0.89	0.00 - 0.00
		7.06	2000/05/15	1.08	0.00 - 0.00
	USDOE	7.08	2000/09/01	1.03	0.87 - 1.18
		7.10	2000/09/01	1.12	0.86 - 1.16
Ba-133	RPB	7.09	2000/10/03	1.54	0.91 - 1.27
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C-14 #2	RPB	7.09	2000/05/25	0.95	0.88 - 1.13
C-14 #3	RPB	7.09	2000/05/25	0.91	0.85 - 1.10
Cd-109	NTS	7.04	2000/05/15	0.98	0.00 - 0.00
		7.06	2000/05/15	1.04	0.00 - 0.00
		7.05	2000/05/15	1.15	0.00 - 0.00
		7.07	2000/05/15	0.86	0.00 - 0.00
Ce-139	NTS	7.04	2000/05/15	1.02	0.00 - 0.00
		7.06	2000/05/15	1.07	0.00 - 0.00
		7.07	2000/05/15	0.87	0.00 - 0.00
Co-57	NTS	7.04	2000/05/15	1.04	0.00 - 0.00
		7.06	2000/05/15	0.98	0.00 - 0.00
		7.07	2000/05/15	0.83	0.00 - 0.00
	RPB	7.09	2000/10/03	1.09	0.90 - 1.11
Co-57 r	USDOE	7.10	2000/09/01	0.89	0.93 - 1.13
	RPB	7.09	2000/10/03	0.79	0.90 - 1.11
Co-60	NTS	7.04	2000/05/15	1.05	0.00 - 0.00
		7.06	2000/05/15	1.08	0.00 - 0.00
		7.05	2000/05/15	1.12	0.00 - 0.00
		7.07	2000/05/15	0.87	0.00 - 0.00
	RPB	7.09	2000/10/03	1.24	0.92 - 1.11
		7.08	2000/09/01	0.95	0.94 - 1.03
		7.10	2000/09/01	0.97	0.96 - 1.10
		7.12	2000/09/01	1.04	0.93 - 1.16
Co-60 r	RPB	7.09	2000/10/03	0.95	0.92 - 1.11
Cs-137	NTS	7.06	2000/05/15	1.17	0.00 - 0.00
		7.07	2000/05/15	0.75	0.00 - 0.00
	RPB	7.09	2000/10/03	1.26	0.89 - 1.10
		7.08	2000/09/01	0.94	0.93 - 1.05
		7.10	2000/09/01	1.05	0.99 - 1.16
		7.11	2000/09/01	0.88	0.95 - 1.12
		7.12	2000/09/01	1.11	0.94 - 1.13
Cs-137 r	RPB	7.09	2000/10/03	0.93	0.89 - 1.10

Table 7.03 (continued): Comparison of QA Agent, All Participants and NB Power

Analysis	Agent	Table No.	Sample Date	NB Power/Agent	*All Participants
H-3	NTS	7.06	2000/05/15	1.08	0.00 - 0.00
	USDOE	7.08	2000/09/01	2.44	1.02 - 1.35
H-3 #1	RPB	7.09	2000/04/06	0.92	0.77 - 1.15
H-3 #2	RPB	7.09	2000/04/06	0.93	0.87 - 1.11
H-3 #3	RPB	7.09	2000/04/06	0.87	0.80 - 1.11
Hg-203	NTS	7.06	2000/05/15	0.80	0.00 - 0.00
		7.07	2000/05/15	0.96	0.00 - 0.00
K-40	USDOE	7.11	2000/09/01	0.91	0.93 - 1.17
		7.12	2000/09/01	1.07	0.93 - 1.16
Mn-54	USDOE	7.10	2000/09/01	1.02	0.96 - 1.15
Sn-113	NTS	7.06	2000/05/15	0.90	0.00 - 0.00
		7.07	2000/05/15	1.00	0.00 - 0.00
Sr-89	NTS	7.04	2000/05/15	0.42	0.00 - 0.00
		7.06	2000/05/15	1.00	0.00 - 0.00
Sr-90	NTS	7.04	2000/05/15	1.12	0.00 - 0.00
		7.06	2000/05/15	1.11	0.00 - 0.00
	USDOE	7.08	2000/09/01	0.95	0.86 - 1.11
		7.10	2000/09/01	0.91	0.71 - 1.22
Y-88	NTS	7.06	2000/05/15	0.99	0.00 - 0.00
		7.05	2000/05/15	1.24	0.00 - 0.00
		7.07	2000/05/15	0.89	0.00 - 0.00

Table 7.04: NTS Air Filter

Analysis	Sample Date	NTS	*All Participants (pCi/filter $\pm$ 2 sigma)	NB Power (pCi/filter $\pm$ 2 sigma)	NB Power/ NTS (ratio)
ALPHA	2000/05/15	36 $\pm$ 4	0 $\pm$ 0	36 $\pm$ 2	0.99
BETA	2000/05/15	179 $\pm$ 18	0 $\pm$ 0	159 $\pm$ 5	0.89
Cd-109	2000/05/15	185 $\pm$ 10	0 $\pm$ 0	180 $\pm$ 22	0.98
Ce-139	2000/05/15	6 $\pm$ 0	0 $\pm$ 0	6 $\pm$ 1	1.02
Co-57	2000/05/15	4 $\pm$ 0	0 $\pm$ 0	5 $\pm$ 1	1.04
Co-60	2000/05/15	10 $\pm$ 0	0 $\pm$ 0	10 $\pm$ 2	1.05
Sr-89	2000/05/15	11 $\pm$ 1	0 $\pm$ 0	5 $\pm$ 1	0.42
Sr-90	2000/05/15	8 $\pm$ 1	0 $\pm$ 0	8 $\pm$ 1	1.12

* : Excluding those results significantly different from the population mean.

Table 7.05: NTS Food

Analysis	Sample Date	NTS	*All Participants (pCi/kg $\pm$ 2 sigma)	NB Power (pCi/kg $\pm$ 2 sigma)	NB Power/ NTS (ratio)
Cd-109	2000/05/15	123 $\pm$ 12	0 $\pm$ 0	141 $\pm$ 24	1.15
Co-60	2000/05/15	6 $\pm$ 1	0 $\pm$ 0	7 $\pm$ 1	1.12
Y-88	2000/05/15	11 $\pm$ 1	0 $\pm$ 0	13 $\pm$ 2	1.24

* : Excluding those results significantly different from the population mean.

Table 7.06: NTS Water

Analysis	Sample Date	NTS	*All Participants (pCi/L $\pm$ 2 sigma)	NB Power (pCi/L $\pm$ 2 sigma)	NB Power/ NTS (ratio)
ALPHA	2000/05/15	24 $\pm$ 2	0 $\pm$ 0	26 $\pm$ 2	1.08
BETA	2000/05/15	30 $\pm$ 3	0 $\pm$ 0	33 $\pm$ 2	1.08
C-14	2000/05/15	352 $\pm$ 35	0 $\pm$ 0	294 $\pm$ 98	0.84
Cd-109	2000/05/15	308 $\pm$ 31	0 $\pm$ 0	319 $\pm$ 37	1.04
Ce-139	2000/05/15	9 $\pm$ 1	0 $\pm$ 0	10 $\pm$ 1	1.07
Co-57	2000/05/15	7 $\pm$ 1	0 $\pm$ 0	7 $\pm$ 1	0.98
Co-60	2000/05/15	16 $\pm$ 2	0 $\pm$ 0	17 $\pm$ 2	1.08
Cs-137	2000/05/15	11 $\pm$ 1	0 $\pm$ 0	13 $\pm$ 2	1.17
H-3	2000/05/15	939 $\pm$ 94	0 $\pm$ 0	1010 $\pm$ 158	1.08
Hg-203	2000/05/15	15 $\pm$ 2	0 $\pm$ 0	12 $\pm$ 2	0.80
Sn-113	2000/05/15	15 $\pm$ 1	0 $\pm$ 0	13 $\pm$ 2	0.90
Sr-89	2000/05/15	17 $\pm$ 2	0 $\pm$ 0	17 $\pm$ 2	1.00
Sr-90	2000/05/15	24 $\pm$ 2	0 $\pm$ 0	27 $\pm$ 2	1.11
Y-88	2000/05/15	26 $\pm$ 3	0 $\pm$ 0	26 $\pm$ 3	0.99

* : Excluding those results significantly different from the population mean.

Table 7.03 (continued): Comparison of QA Agent, All Participants and NB Power

Analysis	Agent	Table No.	Sample Date	NB Power/Agent	*All Participants
H-3	NTS	7.06	2000/05/15	1.08	0.00 - 0.00
	USDOE	7.08	2000/09/01	2.44	1.02 - 1.35
H-3 #1	RPB	7.09	2000/04/06	0.92	0.77 - 1.15
H-3 #2	RPB	7.09	2000/04/06	0.93	0.87 - 1.11
H-3 #3	RPB	7.09	2000/04/06	0.87	0.80 - 1.11
Hg-203	NTS	7.06	2000/05/15	0.80	0.00 - 0.00
		7.07	2000/05/15	0.96	0.00 - 0.00
K-40	USDOE	7.11	2000/09/01	0.91	0.93 - 1.17
		7.12	2000/09/01	1.07	0.93 - 1.16
Mn-54	USDOE	7.10	2000/09/01	1.02	0.96 - 1.15
Sn-113	NTS	7.06	2000/05/15	0.90	0.00 - 0.00
		7.07	2000/05/15	1.00	0.00 - 0.00
Sr-89	NTS	7.04	2000/05/15	0.42	0.00 - 0.00
		7.06	2000/05/15	1.00	0.00 - 0.00
Sr-90	NTS	7.04	2000/05/15	1.12	0.00 - 0.00
		7.06	2000/05/15	1.11	0.00 - 0.00
	USDOE	7.08	2000/09/01	0.95	0.86 - 1.11
		7.10	2000/09/01	0.91	0.71 - 1.22
Y-88	NTS	7.06	2000/05/15	0.99	0.00 - 0.00
		7.05	2000/05/15	1.24	0.00 - 0.00
		7.07	2000/05/15	0.89	0.00 - 0.00

Table 7.04: NTS Air Filter

Analysis	Sample Date	NTS	*All Participants (pCi/filter $\pm$ 2 sigma)	NB Power (pCi/filter $\pm$ 2 sigma)	NB Power/ NTS (ratio)
ALPHA	2000/05/15	36 $\pm$ 4	0 $\pm$ 0	36 $\pm$ 2	0.99
BETA	2000/05/15	179 $\pm$ 18	0 $\pm$ 0	159 $\pm$ 5	0.89
Cd-109	2000/05/15	185 $\pm$ 10	0 $\pm$ 0	180 $\pm$ 22	0.98
Ce-139	2000/05/15	6 $\pm$ 0	0 $\pm$ 0	6 $\pm$ 1	1.02
Co-57	2000/05/15	4 $\pm$ 0	0 $\pm$ 0	5 $\pm$ 1	1.04
Co-60	2000/05/15	10 $\pm$ 0	0 $\pm$ 0	10 $\pm$ 2	1.05
Sr-89	2000/05/15	11 $\pm$ 1	0 $\pm$ 0	5 $\pm$ 1	0.42
Sr-90	2000/05/15	8 $\pm$ 1	0 $\pm$ 0	8 $\pm$ 1	1.12

* : Excluding those results significantly different from the population mean.

Table 7.05: NTS Food

Analysis	Sample Date	NTS	*All Participants (pCi/kg $\pm$ 2 sigma)	NB Power (pCi/kg $\pm$ 2 sigma)	NB Power/ NTS (ratio)
Cd-109	2000/05/15	123 $\pm$ 12	0 $\pm$ 0	141 $\pm$ 24	1.15
Co-60	2000/05/15	6 $\pm$ 1	0 $\pm$ 0	7 $\pm$ 1	1.12
Y-88	2000/05/15	11 $\pm$ 1	0 $\pm$ 0	13 $\pm$ 2	1.24

* : Excluding those results significantly different from the population mean.

Table 7.06: NTS Water

Analysis	Sample Date	NTS	*All Participants (pCi/L $\pm$ 2 sigma)	NB Power (pCi/L $\pm$ 2 sigma)	NB Power/ NTS (ratio)
ALPHA	2000/05/15	24 $\pm$ 2	0 $\pm$ 0	26 $\pm$ 2	1.08
BETA	2000/05/15	30 $\pm$ 3	0 $\pm$ 0	33 $\pm$ 2	1.08
C-14	2000/05/15	352 $\pm$ 35	0 $\pm$ 0	294 $\pm$ 98	0.84
Cd-109	2000/05/15	308 $\pm$ 31	0 $\pm$ 0	319 $\pm$ 37	1.04
Ce-139	2000/05/15	9 $\pm$ 1	0 $\pm$ 0	10 $\pm$ 1	1.07
Co-57	2000/05/15	7 $\pm$ 1	0 $\pm$ 0	7 $\pm$ 1	0.98
Co-60	2000/05/15	16 $\pm$ 2	0 $\pm$ 0	17 $\pm$ 2	1.08
Cs-137	2000/05/15	11 $\pm$ 1	0 $\pm$ 0	13 $\pm$ 2	1.17
H-3	2000/05/15	939 $\pm$ 94	0 $\pm$ 0	1010 $\pm$ 158	1.08
Hg-203	2000/05/15	15 $\pm$ 2	0 $\pm$ 0	12 $\pm$ 2	0.80
Sn-113	2000/05/15	15 $\pm$ 1	0 $\pm$ 0	13 $\pm$ 2	0.90
Sr-89	2000/05/15	17 $\pm$ 2	0 $\pm$ 0	17 $\pm$ 2	1.00
Sr-90	2000/05/15	24 $\pm$ 2	0 $\pm$ 0	27 $\pm$ 2	1.11
Y-88	2000/05/15	26 $\pm$ 3	0 $\pm$ 0	26 $\pm$ 3	0.99

* : Excluding those results significantly different from the population mean.

Table 7.07: NTS Charcoal Cartridge

Analysis	Sample Date	NTS	*All Participants (pCi/cart $\pm$ 2 sigma)	NB Power (pCi/cart $\pm$ 2 sigma)	NB Power/ NTS (ratio)
Cd-109	2000/05/15	76860 $\pm$	0 $\pm$ 0	66300 $\pm$ 4520	0.86
Ce-139	2000/05/15	2328 $\pm$ 233	0 $\pm$ 0	2030 $\pm$ 118	0.87
Co-57	2000/05/15	1803 $\pm$ 270	0 $\pm$ 0	1490 $\pm$ 86	0.83
Co-60	2000/05/15	4027 $\pm$ 403	0 $\pm$ 0	3500 $\pm$ 146	0.87
Cs-137	2000/05/15	2522 $\pm$ 378	0 $\pm$ 0	1900 $\pm$ 113	0.75
Hg-203	2000/05/15	3850 $\pm$ 385	0 $\pm$ 0	3700 $\pm$ 218	0.96
Sn-113	2000/05/15	3693 $\pm$ 369	0 $\pm$ 0	3680 $\pm$ 215	1.00
Y-88	2000/05/15	6586 $\pm$ 659	0 $\pm$ 0	5860 $\pm$ 243	0.89

* : Excluding those results significantly different from the population mean.

Table 7.08: USDOE Water

Analysis	Sample Date	USDOE	*All Participants (pCi/L $\pm$ 2 sigma)	NB Power (pCi/L $\pm$ 2 sigma)	NB Power/ USDOE (ratio)
ALPHA	2000/09/01	1070 $\pm$	1061 $\pm$ 154	905 $\pm$ 55	0.85
BETA	2000/09/01	950 $\pm$ 90	975 $\pm$ 145	979 $\pm$ 54	1.03
Co-60	2000/09/01	74 $\pm$ 3	73 $\pm$ 3	70 $\pm$ 4	0.95
Cs-134	2000/09/01	0 $\pm$ 0	0 $\pm$ 0	6 $\pm$ 1	
Cs-137	2000/09/01	67 $\pm$ 4	66 $\pm$ 4	63 $\pm$ 5	0.94
H-3	2000/09/01	91 $\pm$ 0	108 $\pm$ 15	223 $\pm$ 10	2.44
Sr-90	2000/09/01	5 $\pm$ 0	4 $\pm$ 1	4 $\pm$ 0	0.95

* : Excluding those results significantly different from the population mean.

Table 7.09: RPB Urine

Analysis	Sample Date	RPB Bq/L $\pm$ 2 sigma	*All Participants Bq/L $\pm$ 2 sigma	NB Power Bq/L $\pm$ 2 sigma	NB Power/ RPB
Ba-133	2000/10/03	55 $\pm$ 0	60 $\pm$ 10	84 $\pm$ 8	1.54
Ba-133 r	2000/10/03	55 $\pm$ 0	60 $\pm$ 10	57 $\pm$ 6	1.04
C-14 #1	2000/05/25	1190 $\pm$ 0	1140 $\pm$ 82	1120 $\pm$ 53	0.94
C-14 #2	2000/05/25	23800 $\pm$ 0	23900 $\pm$ 3070	22500 $\pm$ 425	0.95
C-14 #3	2000/05/25	474000 $\pm$ 0	461000 $\pm$ 58600	432000 $\pm$ 1640	0.91
Co-57	2000/10/03	3734 $\pm$ 0	3756 $\pm$ 396	4057 $\pm$ 302	1.09
Co-57 r	2000/10/03	3734 $\pm$ 0	3756 $\pm$ 396	2953 $\pm$ 117	0.79
Co-60	2000/10/03	63 $\pm$ 0	64 $\pm$ 6	77 $\pm$ 4	1.24
Co-60 r	2000/10/03	63 $\pm$ 0	64 $\pm$ 6	60 $\pm$ 4	0.95
Cs-137	2000/10/03	111 $\pm$ 0	110 $\pm$ 12	139 $\pm$ 9	1.26
Cs-137 r	2000/10/03	111 $\pm$ 0	110 $\pm$ 12	103 $\pm$ 7	0.93
H-3 #1	2000/04/06	25200 $\pm$ 0	24200 $\pm$ 4710	23300 $\pm$ 693	0.92
H-3 #2	2000/04/06	315000 $\pm$ 0	312000 $\pm$ 37500	294000 $\pm$ 5000	0.93
H-3 #3	2000/04/06	9E+006 $\pm$ 0E+001	8E+006 $\pm$ 1E+006	8E+006 $\pm$ 1E+005	0.87

* : Excluding those results significantly different from the population mean.

Table 7.10: USDOE Air Filter

Analysis	Sample Date	USDOE (Bq/filter $\pm$ 2 sigma)	*All Participants (Bq/filter $\pm$ 2 sigma)	NB Power (Bq/filter $\pm$ 2 sigma)	NB Power/ USDOE
ALPHA	2000/09/01	2 $\pm$ 0	2 $\pm$ 0	2 $\pm$ 0	1.02
BETA	2000/09/01	2 $\pm$ 0	2 $\pm$ 0	2 $\pm$ 0	1.12
Co-57	2000/09/01	15 $\pm$ 0	15 $\pm$ 1	13 $\pm$ 1	0.89
Co-60	2000/09/01	8 $\pm$ 0	9 $\pm$ 1	8 $\pm$ 0	0.97
Cs-137	2000/09/01	7 $\pm$ 0	8 $\pm$ 1	8 $\pm$ 1	1.05
Mn-54	2000/09/01	43 $\pm$ 1	46 $\pm$ 4	44 $\pm$ 3	1.02
Sr-90	2000/09/01	2 $\pm$ 0	2 $\pm$ 0	2 $\pm$ 0	0.91

* : Excluding those results significantly different from the population mean.

Table 7.07: NTS Charcoal Cartridge

Analysis	Sample Date	NTS	*All Participants (pCi/cart $\pm$ 2 sigma)	NB Power (pCi/cart $\pm$ 2 sigma)	NB Power/ NTS (ratio)
Cd-109	2000/05/15	76860 $\pm$	0 $\pm$ 0	66300 $\pm$ 4520	0.86
Ce-139	2000/05/15	2328 $\pm$ 233	0 $\pm$ 0	2030 $\pm$ 118	0.87
Co-57	2000/05/15	1803 $\pm$ 270	0 $\pm$ 0	1490 $\pm$ 86	0.83
Co-60	2000/05/15	4027 $\pm$ 403	0 $\pm$ 0	3500 $\pm$ 146	0.87
Cs-137	2000/05/15	2522 $\pm$ 378	0 $\pm$ 0	1900 $\pm$ 113	0.75
Hg-203	2000/05/15	3850 $\pm$ 385	0 $\pm$ 0	3700 $\pm$ 218	0.96
Sn-113	2000/05/15	3693 $\pm$ 369	0 $\pm$ 0	3680 $\pm$ 215	1.00
Y-88	2000/05/15	6586 $\pm$ 659	0 $\pm$ 0	5860 $\pm$ 243	0.89

* : Excluding those results significantly different from the population mean.

Table 7.08: USDOE Water

Analysis	Sample Date	USDOE	*All Participants (pCi/L $\pm$ 2 sigma)	NB Power (pCi/L $\pm$ 2 sigma)	NB Power/ USDOE (ratio)
ALPHA	2000/09/01	1070 $\pm$	1061 $\pm$ 154	905 $\pm$ 55	0.85
BETA	2000/09/01	950 $\pm$ 90	975 $\pm$ 145	979 $\pm$ 54	1.03
Co-60	2000/09/01	74 $\pm$ 3	73 $\pm$ 3	70 $\pm$ 4	0.95
Cs-134	2000/09/01	0 $\pm$ 0	0 $\pm$ 0	6 $\pm$ 1	
Cs-137	2000/09/01	67 $\pm$ 4	66 $\pm$ 4	63 $\pm$ 5	0.94
H-3	2000/09/01	91 $\pm$ 0	108 $\pm$ 15	223 $\pm$ 10	2.44
Sr-90	2000/09/01	5 $\pm$ 0	4 $\pm$ 1	4 $\pm$ 0	0.95

* : Excluding those results significantly different from the population mean.

Table 7.09: RPB Urine

Analysis	Sample Date	RPB Bq/L $\pm$ 2 sigma	*All Participants Bq/L $\pm$ 2 sigma	NB Power Bq/L $\pm$ 2 sigma	NB Power/ RPB
Ba-133	2000/10/03	55 $\pm$ 0	60 $\pm$ 10	84 $\pm$ 8	1.54
Ba-133 r	2000/10/03	55 $\pm$ 0	60 $\pm$ 10	57 $\pm$ 6	1.04
C-14 #1	2000/05/25	1190 $\pm$ 0	1140 $\pm$ 82	1120 $\pm$ 53	0.94
C-14 #2	2000/05/25	23800 $\pm$ 0	23900 $\pm$ 3070	22500 $\pm$ 425	0.95
C-14 #3	2000/05/25	474000 $\pm$ 0	461000 $\pm$ 58600	432000 $\pm$ 1640	0.91
Co-57	2000/10/03	3734 $\pm$ 0	3756 $\pm$ 396	4057 $\pm$ 302	1.09
Co-57 r	2000/10/03	3734 $\pm$ 0	3756 $\pm$ 396	2953 $\pm$ 117	0.79
Co-60	2000/10/03	63 $\pm$ 0	64 $\pm$ 6	77 $\pm$ 4	1.24
Co-60 r	2000/10/03	63 $\pm$ 0	64 $\pm$ 6	60 $\pm$ 4	0.95
Cs-137	2000/10/03	111 $\pm$ 0	110 $\pm$ 12	139 $\pm$ 9	1.26
Cs-137 r	2000/10/03	111 $\pm$ 0	110 $\pm$ 12	103 $\pm$ 7	0.93
H-3 #1	2000/04/06	25200 $\pm$ 0	24200 $\pm$ 4710	23300 $\pm$ 693	0.92
H-3 #2	2000/04/06	315000 $\pm$ 0	312000 $\pm$ 37500	294000 $\pm$ 5000	0.93
H-3 #3	2000/04/06	9E+006 $\pm$ 0E+001	8E+006 $\pm$ 1E+006	8E+006 $\pm$ 1E+005	0.87

* : Excluding those results significantly different from the population mean.

Table 7.10: USDOE Air Filter

Analysis	Sample Date	USDOE (Bq/filter $\pm$ 2 sigma)	*All Participants (Bq/filter $\pm$ 2 sigma)	NB Power (Bq/filter $\pm$ 2 sigma)	NB Power/ USDOE
ALPHA	2000/09/01	2 $\pm$ 0	2 $\pm$ 0	2 $\pm$ 0	1.02
BETA	2000/09/01	2 $\pm$ 0	2 $\pm$ 0	2 $\pm$ 0	1.12
Co-57	2000/09/01	15 $\pm$ 0	15 $\pm$ 1	13 $\pm$ 1	0.89
Co-60	2000/09/01	8 $\pm$ 0	9 $\pm$ 1	8 $\pm$ 0	0.97
Cs-137	2000/09/01	7 $\pm$ 0	8 $\pm$ 1	8 $\pm$ 1	1.05
Mn-54	2000/09/01	43 $\pm$ 1	46 $\pm$ 4	44 $\pm$ 3	1.02
Sr-90	2000/09/01	2 $\pm$ 0	2 $\pm$ 0	2 $\pm$ 0	0.91

* : Excluding those results significantly different from the population mean.

Table 7.11: USDOE Soil

Analysis	Sample Date	USDOE (Bq/kg $\pm$ 2 sigma)	*All Participants (Bq/kg $\pm$ 2 sigma)	NB Power (Bq/kg $\pm$ 2 sigma)	NB Power/ USDOE
Cs-137	2000/09/01	1020 $\pm$ 51	1055 $\pm$ 91	895 $\pm$ 52	0.88
K-40	2000/09/01	713 $\pm$ 38	749 $\pm$ 83	648 $\pm$ 53	0.91

* : Excluding those results significantly different from the population mean.

Table 7.12: USDOE Vegetation

Analysis	Sample Date	USDOE (Bq/kg $\pm$ 2 sigma)	*All Participants (Bq/kg $\pm$ 2 sigma)	NB Power (Bq/kg $\pm$ 2 sigma)	NB Power/ USDOE
Co-60	2000/09/01	33 $\pm$ 1	34 $\pm$ 4	34 $\pm$ 3	1.04
Cs-137	2000/09/01	867 $\pm$ 44	896 $\pm$ 85	964 $\pm$ 57	1.11
K-40	2000/09/01	639 $\pm$ 34	668 $\pm$ 75	685 $\pm$ 68	1.07

* : Excluding those results significantly different from the population mean.

**Table 7.13: Twelfth International Inter-comparison of Environmental Dosimeters
(preliminary results only)**

TLD Type	Dose (μ Gy)		NB Power/USDOE
	USDOE preliminary results	NB Power	
UD-814AS1	391 $\pm$ 11 (Cs-137)	460 $\pm$ 46	1.18
	161 $\pm$ 10 (field)	165 $\pm$ 16	1.02
	548 $\pm$ 16 (Cs-137 & field)	624 $\pm$ 62	1.14
	391 $\pm$ 11 (Cs-137 & field)	447 $\pm$ 45	1.14
	623 $\pm$ 18 (Cs-137 & field)	708 $\pm$ 71	1.14
UD-814AQ	391 $\pm$ 11 (Cs-137)	442 $\pm$ 44	1.13
	161 $\pm$ 10 (field)	163 $\pm$ 16	1.01
	548 $\pm$ 16 (Cs-137 & field)	618 $\pm$ 62	1.13
	391 $\pm$ 11 (Cs-137 & field)	420 $\pm$ 42	1.07
	623 $\pm$ 18 (Cs-137 & field)	667 $\pm$ 67	1.07

Table 7.14: IAEA Samples

Analysis	Analysis Date	Sample	IAEA (Bq/kg $\pm$ 2s)	NB Power (Bq/kg $\pm$ 2s)	NB Power/ IAEA (ratio)
Am-241	2000/02/29	IAEA Sediment - 1992	318 $\pm$ 8	288 $\pm$ 36	0.91
	2000/02/29	IAEA Cockle - 1992	38 $\pm$ 2	57 $\pm$ 7	1.49
	2000/03/28	IAEA Sediment - 1992	318 $\pm$ 8	385 $\pm$ 45	1.21
	2000/03/29	IAEA Cockle - 1992	38 $\pm$ 2	50 $\pm$ 8	1.32
	2000/04/19	IAEA Sediment - 1990	26 $\pm$ 2	17 $\pm$ 3	0.63
	2000/04/25	IAEA Sediment - 1990	26 $\pm$ 2	34 $\pm$ 7	1.29
Cs-134	2000/03/01	IAEA Milk - 1987	764 $\pm$ 40	770 $\pm$ 226	1.01
	2000/09/05	IAEA Sediment - 1991	463 $\pm$ 9	453 $\pm$ 74	0.98
	2000/09/06	IAEA Sediment - 1991	463 $\pm$ 9	439 $\pm$ 74	0.95
	2000/09/07	IAEA Sediment - 1991	463 $\pm$ 9	426 $\pm$ 70	0.92
Cs-137	2000/02/29	IAEA Sediment - 1992	1108 $\pm$ 32	970 $\pm$ 100	0.88
	2000/02/29	IAEA Cockle - 1992	50 $\pm$ 1	57 $\pm$ 6	1.14
	2000/03/01	IAEA Milk - 1987	2129 $\pm$ 78	1920 $\pm$ 189	0.90
	2000/03/28	IAEA Sediment - 1992	1108 $\pm$ 32	1090 $\pm$ 110	0.98
	2000/03/29	IAEA Cockle - 1992	50 $\pm$ 1	52 $\pm$ 6	1.04
	2000/04/19	IAEA Sediment - 1990	195 $\pm$ 6	184 $\pm$ 20	0.94
	2000/04/20	IAEA Milk - 1989	73 $\pm$ 2	57 $\pm$ 8	0.79
	2000/04/25	IAEA Sediment - 1990	195 $\pm$ 6	198 $\pm$ 21	1.02
	2000/09/05	IAEA Sediment - 1991	5280 $\pm$ 80	4960 $\pm$ 535	0.94
	2000/09/06	IAEA Sediment - 1991	5280 $\pm$ 80	5120 $\pm$ 505	0.97
	2000/09/07	IAEA Sediment - 1991	5280 $\pm$ 80	5070 $\pm$ 500	0.96
	2000/12/12	IAEA Soil - 1994	25 $\pm$ 1	22 $\pm$ 2	0.90
K-40	2000/02/29	IAEA Sediment - 1992	560 $\pm$ 9	658 $\pm$ 109	1.18
	2000/02/29	IAEA Cockle - 1992	212 $\pm$ 22	290 $\pm$ 36	1.37
	2000/03/01	IAEA Milk - 1987	539 $\pm$ 32	494 $\pm$ 51	0.92
	2000/03/28	IAEA Sediment - 1992	560 $\pm$ 9	692 $\pm$ 96	1.24
	2000/03/29	IAEA Cockle - 1992	212 $\pm$ 22	276 $\pm$ 42	1.30
	2000/04/19	IAEA Sediment - 1990	5 $\pm$ 0	105 $\pm$ 24	20.19
	2000/04/20	IAEA Milk - 1989	552 $\pm$ 17	525 $\pm$ 83	0.95
	2000/04/20	IAEA Tuna - 1989	391 $\pm$ 13	474 $\pm$ 96	1.21
	2000/04/25	IAEA Sediment - 1990	5 $\pm$ 0	77 $\pm$ 19	14.73
	2000/09/05	IAEA Sediment - 1991	424 $\pm$ 8	432 $\pm$ 45	1.02
	2000/09/06	IAEA Sediment - 1991	424 $\pm$ 8	444 $\pm$ 46	1.05
	2000/09/07	IAEA Sediment - 1991	424 $\pm$ 8	436 $\pm$ 45	1.03
	2000/12/12	IAEA Soil - 1994	621 $\pm$ 9	582 $\pm$ 38	0.94
Sb-125	2000/09/05	IAEA Sediment - 1991	77 $\pm$ 2	95 $\pm$ 33	1.23

Table 7.11: USDOE Soil

Analysis	Sample Date	USDOE (Bq/kg $\pm$ 2 sigma)	*All Participants (Bq/kg $\pm$ 2 sigma)	NB Power (Bq/kg $\pm$ 2 sigma)	NB Power/ USDOE
Cs-137	2000/09/01	1020 $\pm$ 51	1055 $\pm$ 91	895 $\pm$ 52	0.88
K-40	2000/09/01	713 $\pm$ 38	749 $\pm$ 83	648 $\pm$ 53	0.91

* : Excluding those results significantly different from the population mean.

Table 7.12: USDOE Vegetation

Analysis	Sample Date	USDOE (Bq/kg $\pm$ 2 sigma)	*All Participants (Bq/kg $\pm$ 2 sigma)	NB Power (Bq/kg $\pm$ 2 sigma)	NB Power/ USDOE
Co-60	2000/09/01	33 $\pm$ 1	34 $\pm$ 4	34 $\pm$ 3	1.04
Cs-137	2000/09/01	867 $\pm$ 44	896 $\pm$ 85	964 $\pm$ 57	1.11
K-40	2000/09/01	639 $\pm$ 34	668 $\pm$ 75	685 $\pm$ 68	1.07

* : Excluding those results significantly different from the population mean.

**Table 7.13: Twelfth International Inter-comparison of Environmental Dosimeters
(preliminary results only)**

TLD Type	Dose (μ Gy)		NB Power/USDOE
	USDOE preliminary results	NB Power	
UD-814AS1	391 $\pm$ 11 (Cs-137)	460 $\pm$ 46	1.18
	161 $\pm$ 10 (field)	165 $\pm$ 16	1.02
	548 $\pm$ 16 (Cs-137 & field)	624 $\pm$ 62	1.14
	391 $\pm$ 11 (Cs-137 & field)	447 $\pm$ 45	1.14
	623 $\pm$ 18 (Cs-137 & field)	708 $\pm$ 71	1.14
UD-814AQ	391 $\pm$ 11 (Cs-137)	442 $\pm$ 44	1.13
	161 $\pm$ 10 (field)	163 $\pm$ 16	1.01
	548 $\pm$ 16 (Cs-137 & field)	618 $\pm$ 62	1.13
	391 $\pm$ 11 (Cs-137 & field)	420 $\pm$ 42	1.07
	623 $\pm$ 18 (Cs-137 & field)	667 $\pm$ 67	1.07

Table 7.14: IAEA Samples

Analysis	Analysis Date	Sample	IAEA (Bq/kg $\pm$ 2s)	NB Power (Bq/kg $\pm$ 2s)	NB Power/ IAEA (ratio)
Am-241	2000/02/29	IAEA Sediment - 1992	318 $\pm$ 8	288 $\pm$ 36	0.91
	2000/02/29	IAEA Cockle - 1992	38 $\pm$ 2	57 $\pm$ 7	1.49
	2000/03/28	IAEA Sediment - 1992	318 $\pm$ 8	385 $\pm$ 45	1.21
	2000/03/29	IAEA Cockle - 1992	38 $\pm$ 2	50 $\pm$ 8	1.32
	2000/04/19	IAEA Sediment - 1990	26 $\pm$ 2	17 $\pm$ 3	0.63
	2000/04/25	IAEA Sediment - 1990	26 $\pm$ 2	34 $\pm$ 7	1.29
Cs-134	2000/03/01	IAEA Milk - 1987	764 $\pm$ 40	770 $\pm$ 226	1.01
	2000/09/05	IAEA Sediment - 1991	463 $\pm$ 9	453 $\pm$ 74	0.98
	2000/09/06	IAEA Sediment - 1991	463 $\pm$ 9	439 $\pm$ 74	0.95
	2000/09/07	IAEA Sediment - 1991	463 $\pm$ 9	426 $\pm$ 70	0.92
Cs-137	2000/02/29	IAEA Sediment - 1992	1108 $\pm$ 32	970 $\pm$ 100	0.88
	2000/02/29	IAEA Cockle - 1992	50 $\pm$ 1	57 $\pm$ 6	1.14
	2000/03/01	IAEA Milk - 1987	2129 $\pm$ 78	1920 $\pm$ 189	0.90
	2000/03/28	IAEA Sediment - 1992	1108 $\pm$ 32	1090 $\pm$ 110	0.98
	2000/03/29	IAEA Cockle - 1992	50 $\pm$ 1	52 $\pm$ 6	1.04
	2000/04/19	IAEA Sediment - 1990	195 $\pm$ 6	184 $\pm$ 20	0.94
	2000/04/20	IAEA Milk - 1989	73 $\pm$ 2	57 $\pm$ 8	0.79
	2000/04/25	IAEA Sediment - 1990	195 $\pm$ 6	198 $\pm$ 21	1.02
	2000/09/05	IAEA Sediment - 1991	5280 $\pm$ 80	4960 $\pm$ 535	0.94
	2000/09/06	IAEA Sediment - 1991	5280 $\pm$ 80	5120 $\pm$ 505	0.97
	2000/09/07	IAEA Sediment - 1991	5280 $\pm$ 80	5070 $\pm$ 500	0.96
	2000/12/12	IAEA Soil - 1994	25 $\pm$ 1	22 $\pm$ 2	0.90
K-40	2000/02/29	IAEA Sediment - 1992	560 $\pm$ 9	658 $\pm$ 109	1.18
	2000/02/29	IAEA Cockle - 1992	212 $\pm$ 22	290 $\pm$ 36	1.37
	2000/03/01	IAEA Milk - 1987	539 $\pm$ 32	494 $\pm$ 51	0.92
	2000/03/28	IAEA Sediment - 1992	560 $\pm$ 9	692 $\pm$ 96	1.24
	2000/03/29	IAEA Cockle - 1992	212 $\pm$ 22	276 $\pm$ 42	1.30
	2000/04/19	IAEA Sediment - 1990	5 $\pm$ 0	105 $\pm$ 24	20.19
	2000/04/20	IAEA Milk - 1989	552 $\pm$ 17	525 $\pm$ 83	0.95
	2000/04/20	IAEA Tuna - 1989	391 $\pm$ 13	474 $\pm$ 96	1.21
	2000/04/25	IAEA Sediment - 1990	5 $\pm$ 0	77 $\pm$ 19	14.73
	2000/09/05	IAEA Sediment - 1991	424 $\pm$ 8	432 $\pm$ 45	1.02
	2000/09/06	IAEA Sediment - 1991	424 $\pm$ 8	444 $\pm$ 46	1.05
	2000/09/07	IAEA Sediment - 1991	424 $\pm$ 8	436 $\pm$ 45	1.03
	2000/12/12	IAEA Soil - 1994	621 $\pm$ 9	582 $\pm$ 38	0.94
Sb-125	2000/09/05	IAEA Sediment - 1991	77 $\pm$ 2	95 $\pm$ 33	1.23

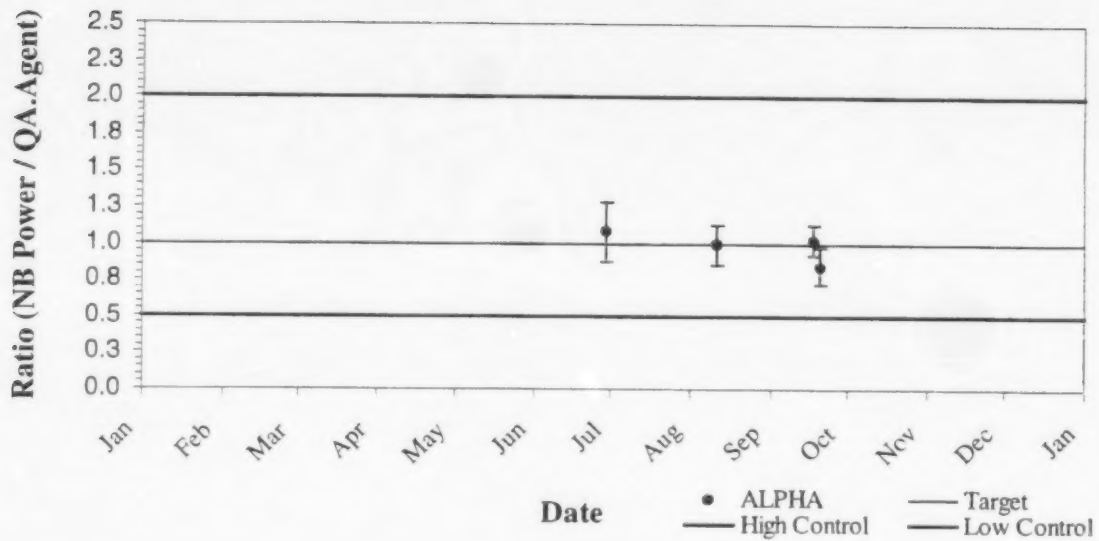


Figure 7.01: Alpha QA Performance (External Agencies)

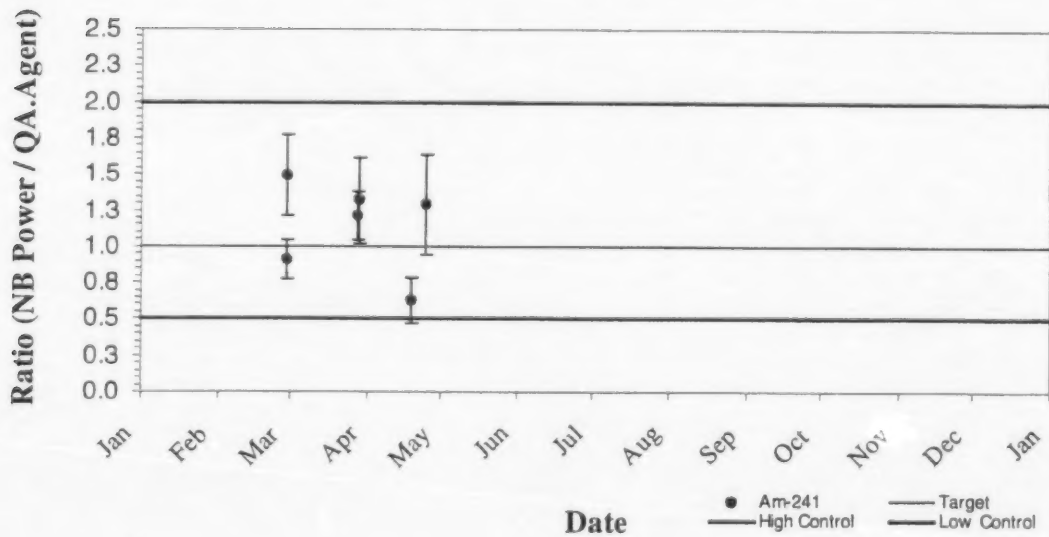


Figure 7.02: Am-241 QA Performance (External Agencies)

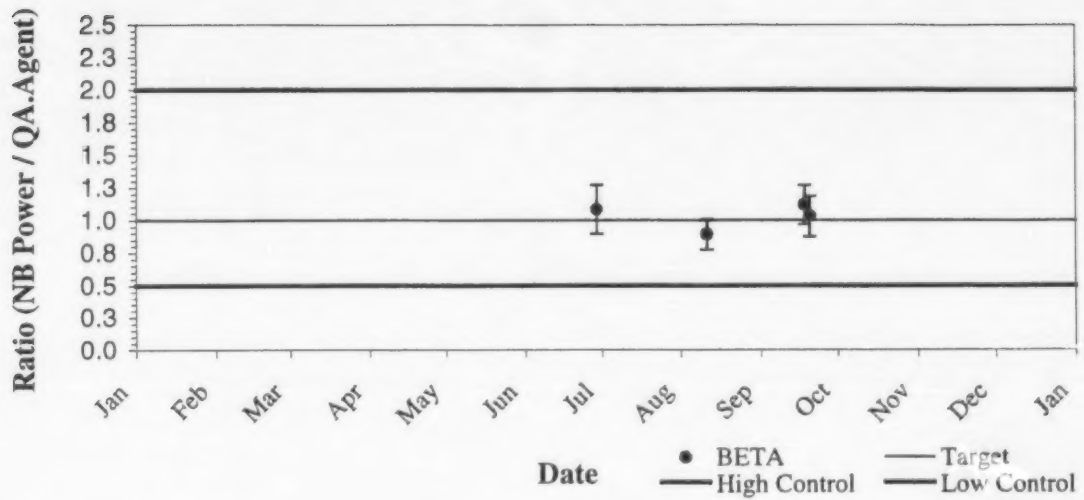


Figure 7.03: Beta QA Performance (External Agencies)

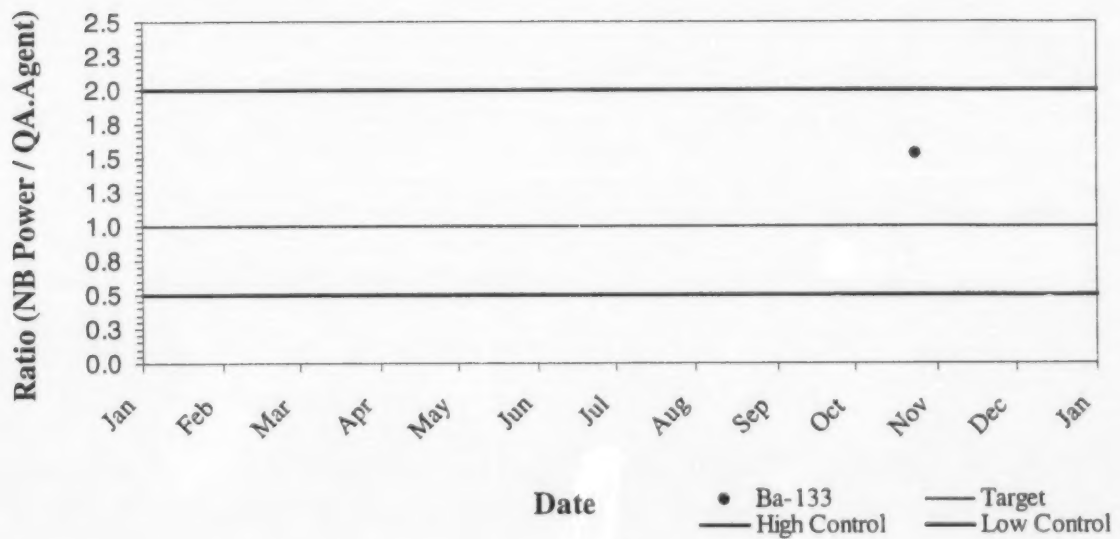


Figure 7.04: Ba-133 QA Performance (External Agencies)

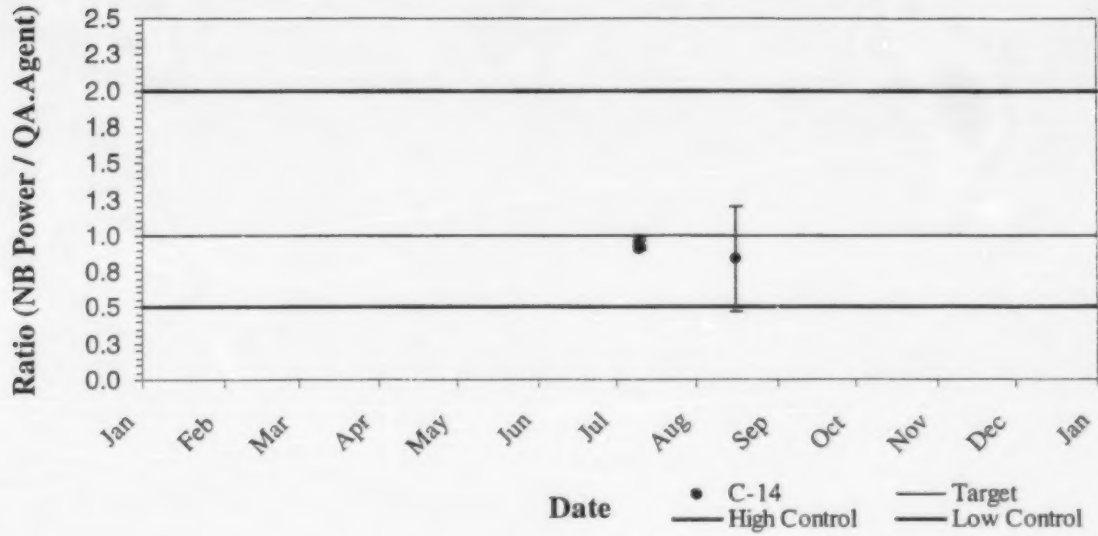


Figure 7.05: C-14 QA Performance (External Agencies)

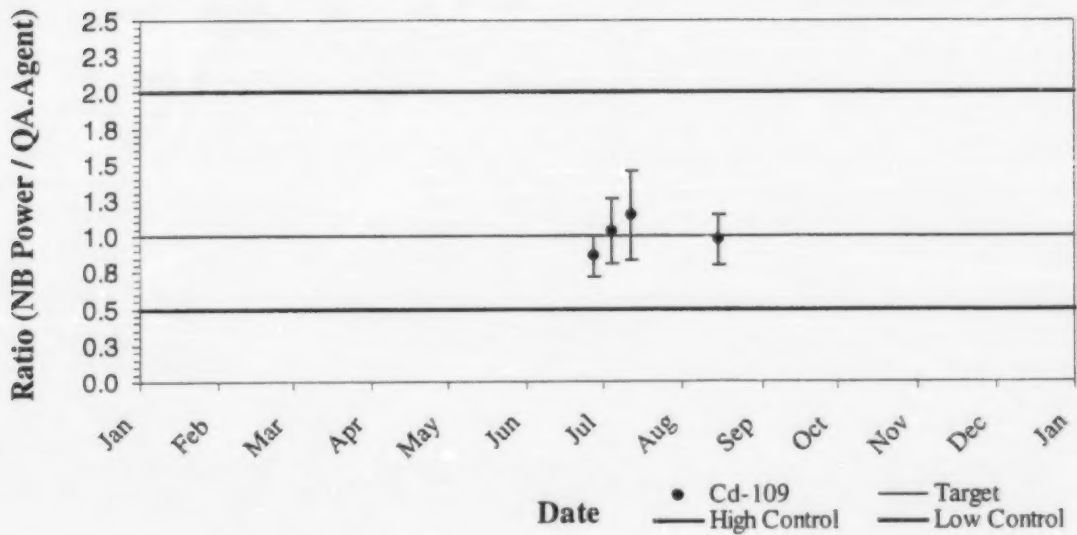


Figure 7.06: Cd-109 QA Performance (External Agencies)

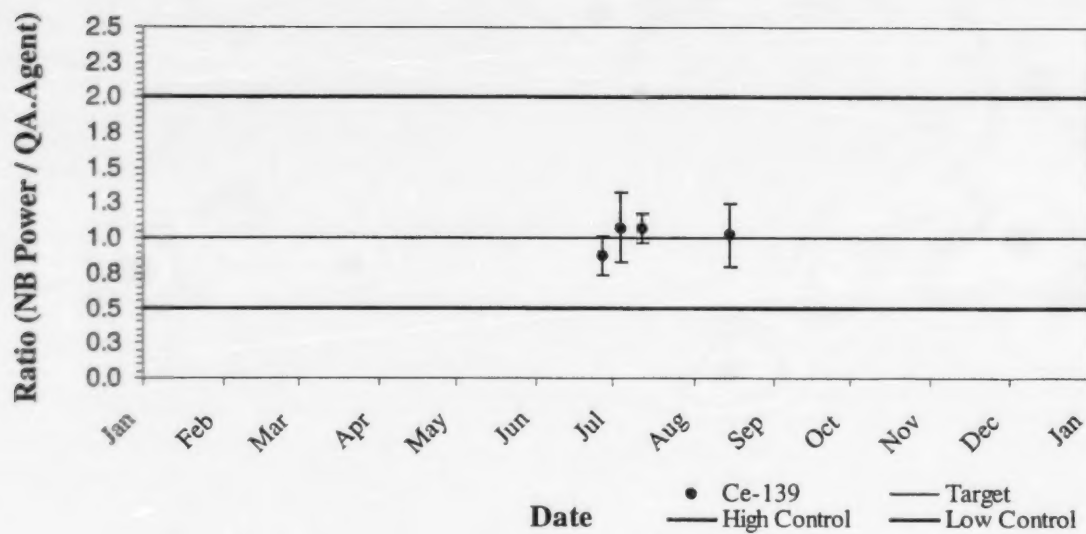


Figure 7.07: Ce-139 QA Performance (External Agencies)

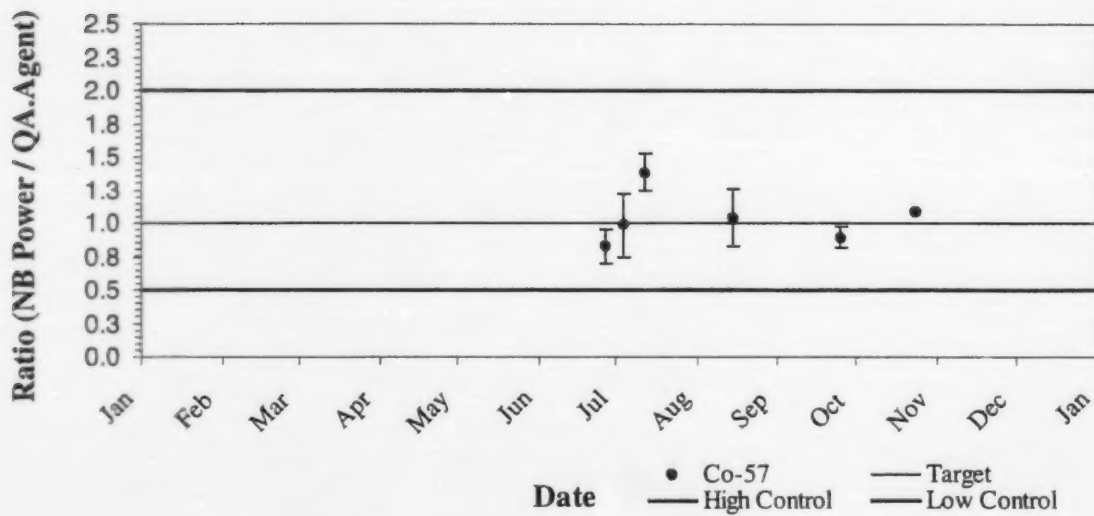


Figure 7.08: Co-57 QA Performance (External Agencies)

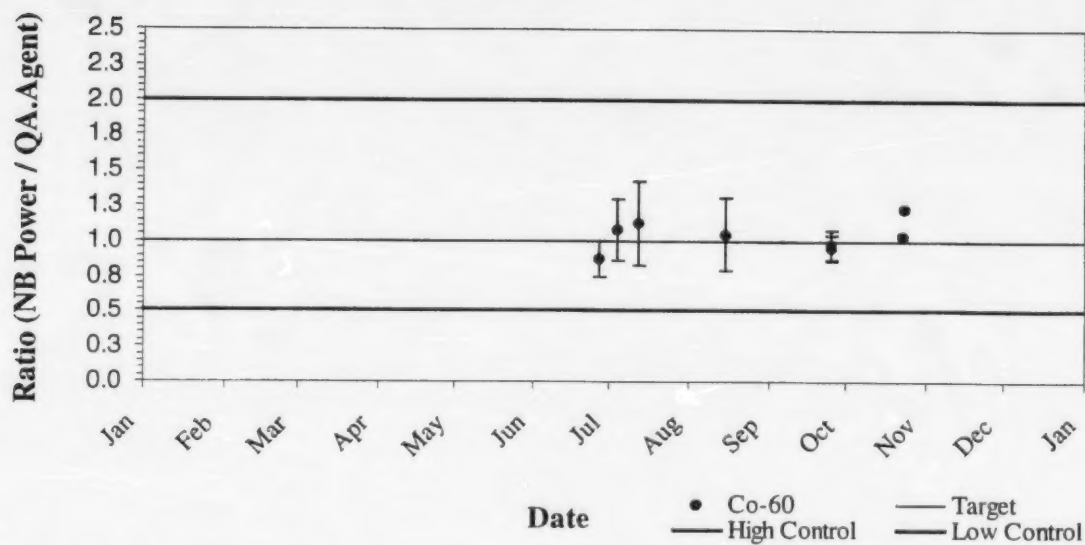


Figure 7.09: Co-60 QA Performance (External Agencies)

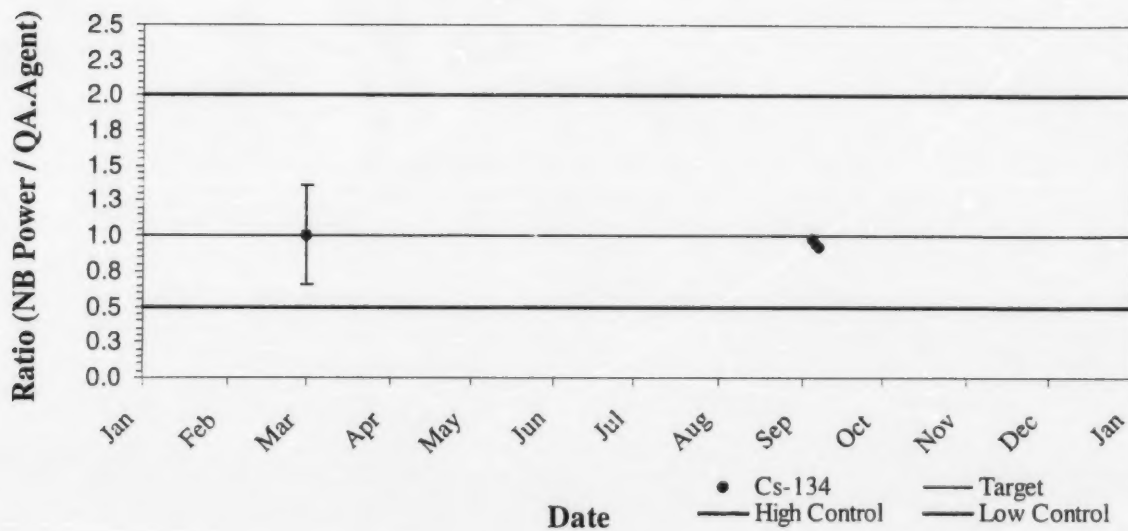


Figure 7.10: Cs-134 QA Performance (External Agencies)

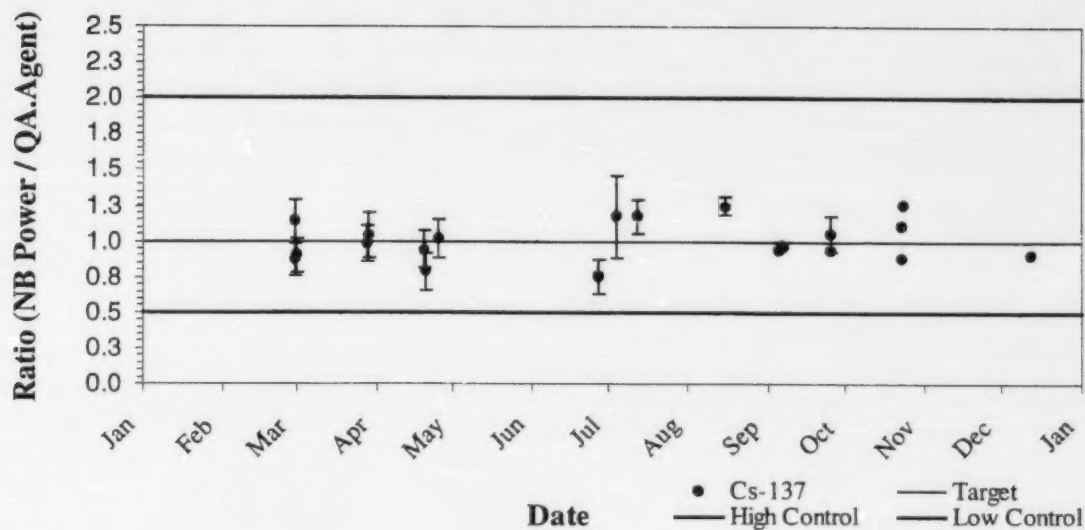


Figure 7.11: Cs-137 QA Performance (External Agencies)

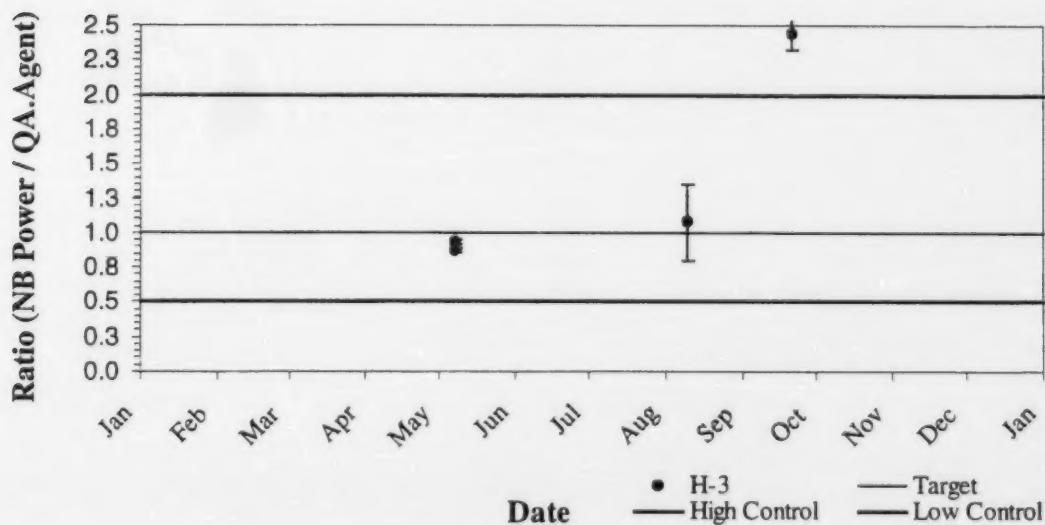


Figure 7.12: H-3 QA Performance (External Agencies)

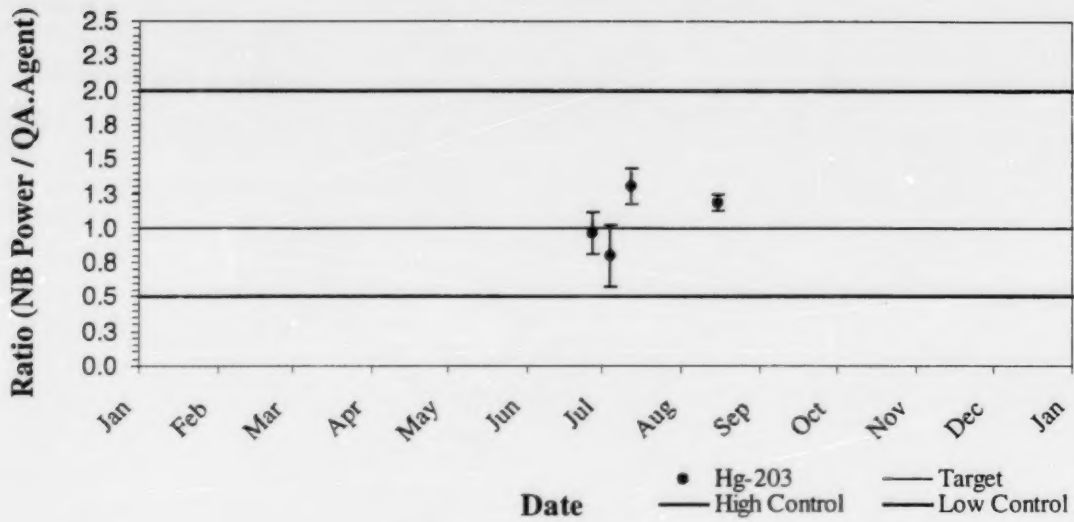


Figure 7.13: Hg-203 QA Performance (External Agencies)

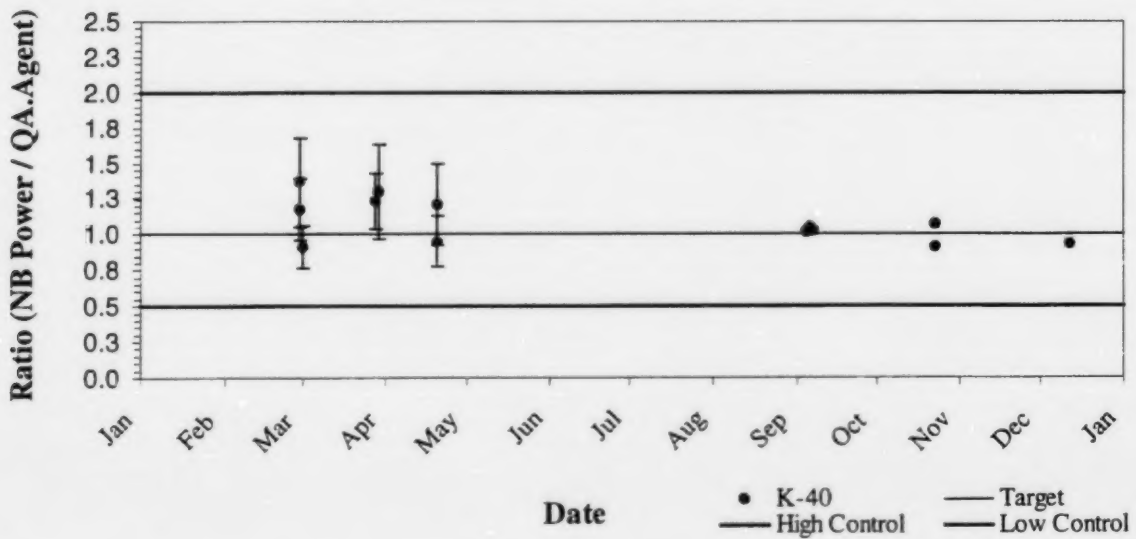


Figure 7.14: K-40 QA Performance (External Agencies)

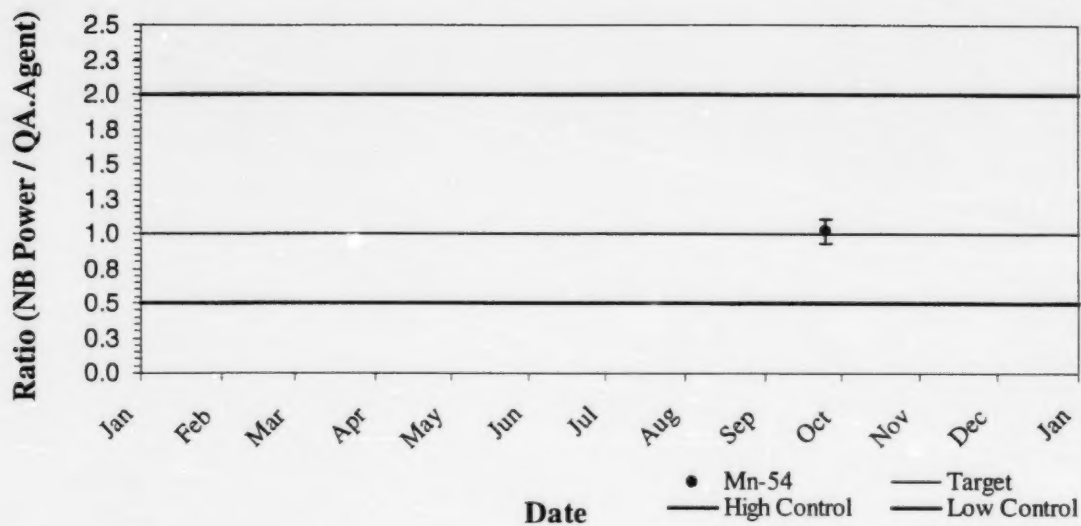


Figure 7.15: Mn-54 QA Performance (External Agencies)

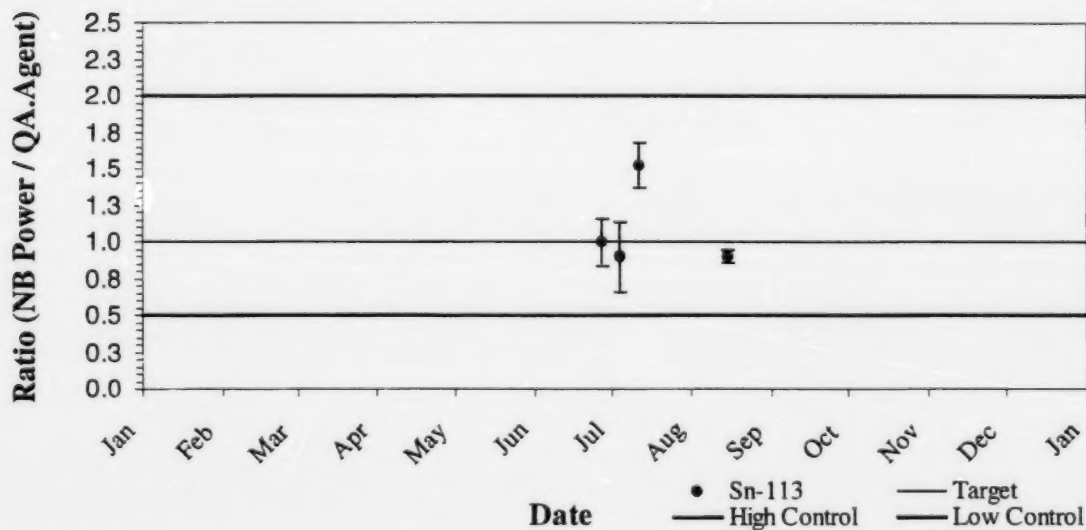


Figure 7.16: Sn-113 QA Performance (External Agencies)

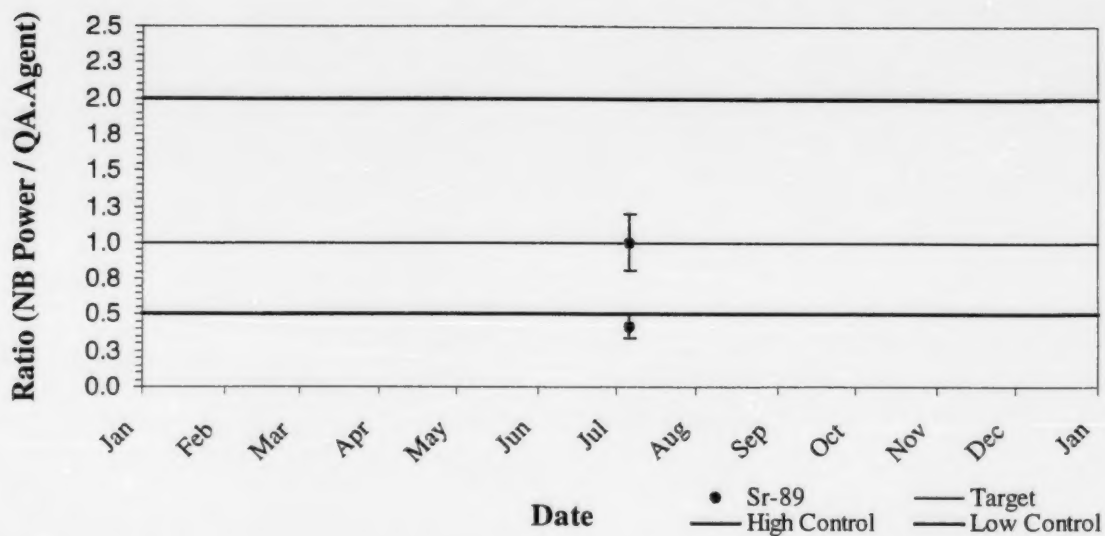


Figure 7.17: Sr-89 QA Performance (External Agencies)

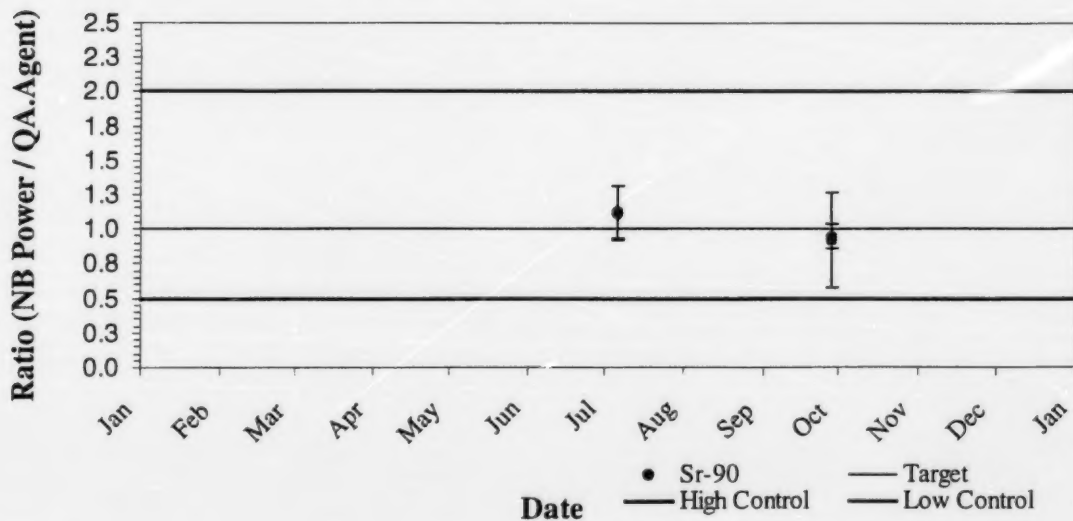


Figure 7.18: Sr-90 QA Performance (External Agencies)

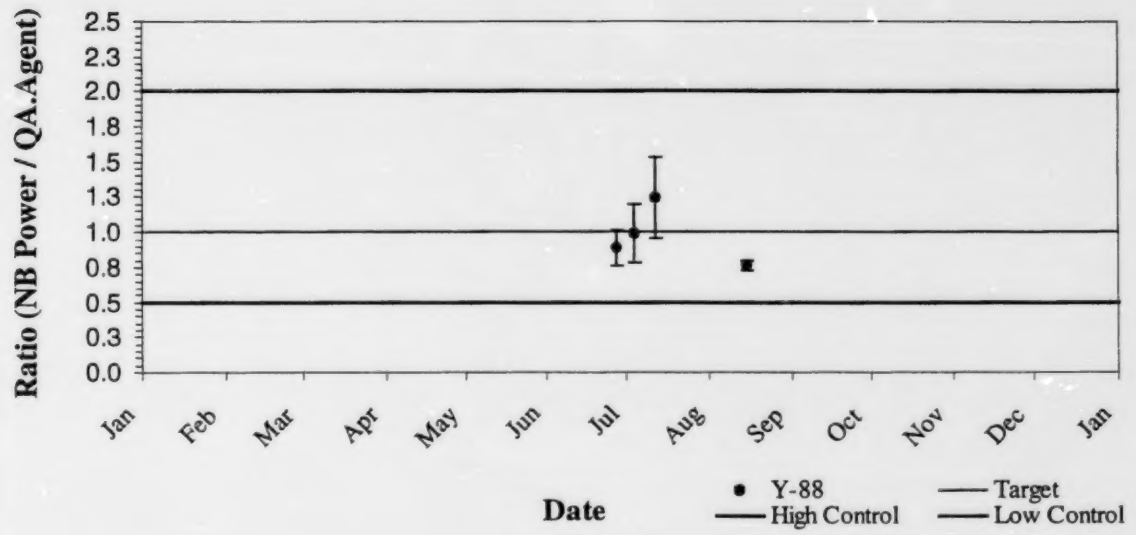


Figure 7.19: Y-88 QA Performance (External Agencies)

7.03 Internal QA

There are four parts to Internal QA:

- 1) duplicate samples – two samples collected at the same time and analysed separately
- 2) replicate analyses – two analyses done on the same sample
- 3) spiked samples – one member of the lab staff spikes a sample and a different person does the analysis
- 4) repeated analyses of calibration standards or stock solutions

Duplicate samples and replicate counts are employed as part of the overall quality assurance program. For those media where two samples can be obtained from the same location at the same time, similar analytical results are expected. This approach demonstrates that the samples are representative of the medium in that area. Where duplicate samples are not possible, e.g. air filters, a sample is counted twice to demonstrate reproducibility in the counting system. Results of performance with these samples gives an indication of how representative our samples are, and how reproducible our measurements are. Tracking of results is done in a spreadsheet and performance is charted. Acceptable performance is defined as overlapping results at the 95% confidence interval for detected values in both samples or counts when the detected values are greater than or equal to 5 times the critical level. See Table 7.14 for the frequency.

Spiked samples are also employed as part of the overall quality assurance program in support of the environmental monitoring program. Similar to External QA, one member of the lab staff spikes a sample and a different person analyses the sample. Results of performance with these samples gives an indication of the quality of measurements. Tracking of results is done in a spreadsheet and performance is charted. Acceptable performance is defined as results within $\pm 10\%$ of the expected value. See Table 7.15 for the frequency.

There were failures in the internal QA of repeated counts on the calibration standards, particularly for two of the nuclides in the mixed nuclide standard. These resulted from large decay corrections applied to relatively small peak areas for short half life nuclides such as Co-57 (272 days) and Cd-109 (462 days) after 5 years of decay (4 to 7 half lives). The H-3 standard in use for internal spikes had also decayed to about 35% of its initial activity and was due to be replaced early in 2001.

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Table 7.14: Internal (Duplicate Samples/Replicate Analyses) QA Frequency

<i>Medium</i>	<i>Duplicate/Replicate</i>	<i>Number of Internal Duplicate Samples/Replicate Analyses per Year</i>	<i>Analyses</i>
Airborne Carbon Dioxide	Replicate analysis, single location	12	LSC C-14
Airborne Iodines	Replicate count, 1 composite set	12	Gamma
Airborne Particulates	Replicate count, single sample	12	Gamma, Alpha/Beta
Garden Vegetables	Replicate analysis & duplicate samples	6	Gamma
Milk	Duplicate sample, indicator station	12	Gamma
Parshall Flume	Replicate analysis	12	LSC H-3
LEM Composite	Replicate count Replicate analysis	12	Gamma Alpha/Beta Sr-89,90
Sea Food	Replicate analysis	6	Gamma
Sediment / Soil	Duplicate sample	6	Gamma
Environmental Gamma	Duplicate sample – M02	4	TLD

Table 7.15: Internal (Spikes) Quality Assurance Frequency

<i>Media</i>	<i>Analysis</i>	<i>Number of Internal Spikes per Year</i>
Filters	Gross Alpha/Beta	6
	Gamma	6
	Sr-89,90	6
Environmental Gamma	TLD	2
Milk	Gamma	2
Soil/Sediment	Gamma	3
Water	Gross Alpha/Beta	6
	H-3	6
	C-14	6
	Gamma	6
	Sr-89,90	6
Charcoal Cartridges	Gamma	6
Food	Gamma	6



Table 7.14: Internal (Duplicate Samples/Replicate Analyses) QA Frequency

<i>Medium</i>	<i>Duplicate/Replicate</i>	<i>Number of Internal Duplicate Samples/Replicate Analyses per Year</i>	<i>Analyses</i>
Airborne Carbon Dioxide	Replicate analysis, single location	12	LSC C-14
Airborne Iodines	Replicate count, 1 composite set	12	Gamma
Airborne Particulates	Replicate count, single sample	12	Gamma, Alpha/Beta
Garden Vegetables	Replicate analysis & duplicate samples	6	Gamma
Milk	Duplicate sample, indicator station	12	Gamma
Parshall Flume	Replicate analysis	12	LSC H-3
LEM Composite	Replicate count Replicate analysis	12	Gamma Alpha/Beta Sr-89,90
Sea Food	Replicate analysis	6	Gamma
Sediment / Soil	Duplicate sample	6	Gamma
Environmental Gamma	Duplicate sample – M02	4	TLD

Table 7.15: Internal (Spikes) Quality Assurance Frequency

<i>Media</i>	<i>Analysis</i>	<i>Number of Internal Spikes per Year</i>
Filters	Gross Alpha/Beta	6
	Gamma	6
	Sr-89,90	6
Environmental Gamma	TLD	2
Milk	Gamma	2
Soil/Sediment	Gamma	3
Water	Gross Alpha/Beta	6
	H-3	6
	C-14	6
	Gamma	6
	Sr-89,90	6
Charcoal Cartridges	Gamma	6
Food	Gamma	6

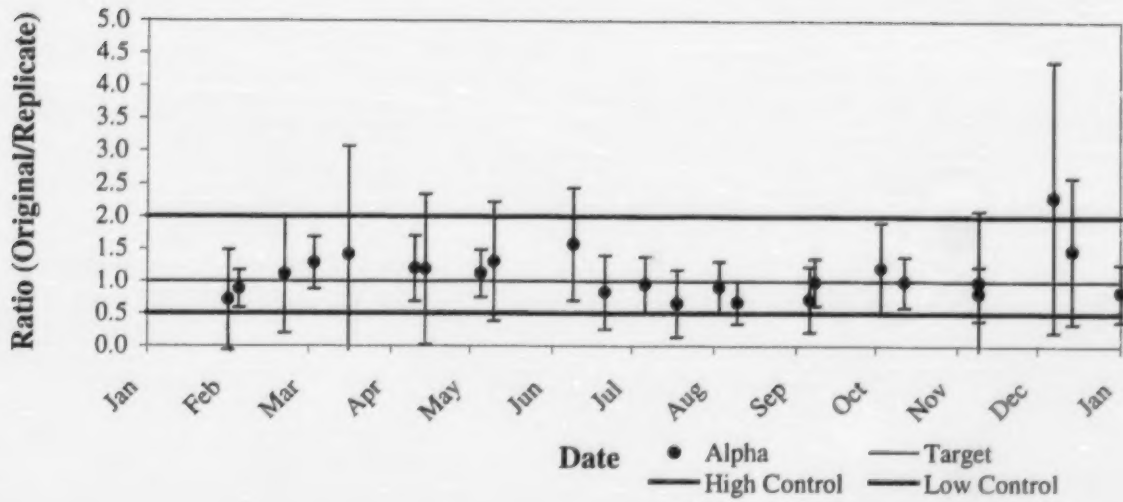


Figure 7.20: Alpha QA Performance (Internal - Duplicate Samples or Replicate Analyses)

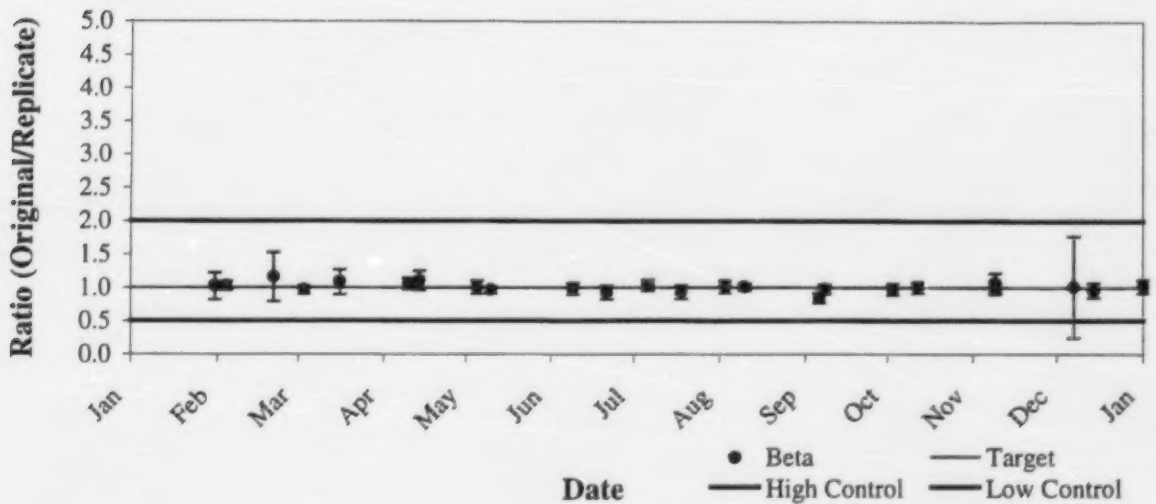


Figure 7.21: Beta QA Performance (Internal - Duplicate Samples or Replicate Analyses)

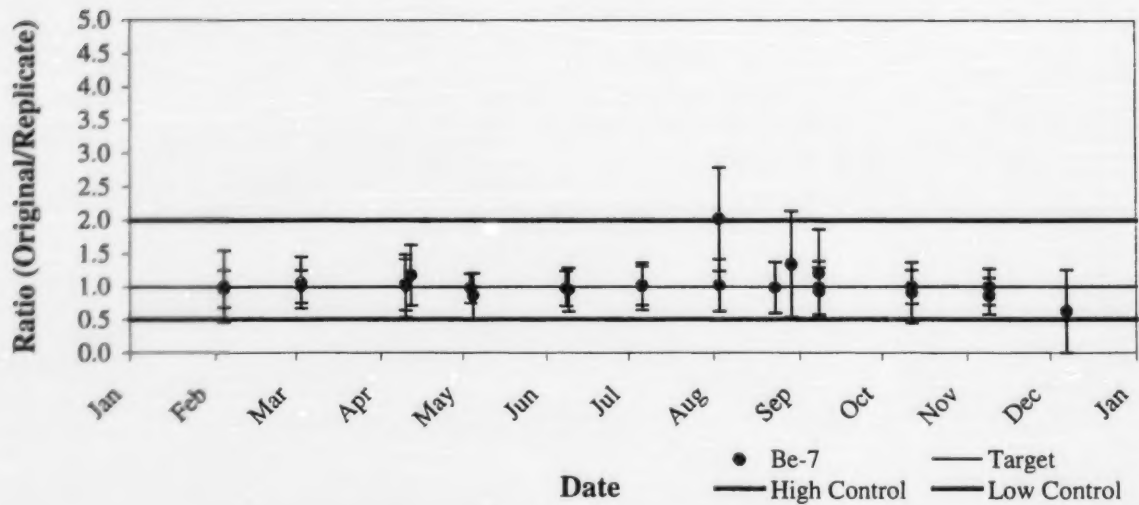


Figure 7.22: Be-7 QA Performance (Internal - Duplicate Samples or Replicate Analyses)

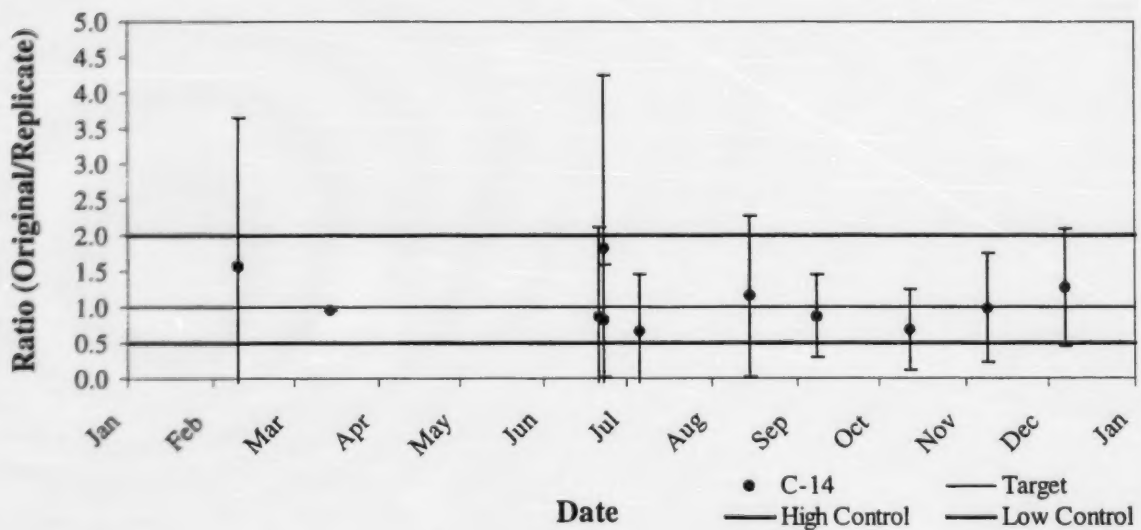


Figure 7.23: C-14 QA Performance (Internal - Duplicate Samples or Replicate Analyses)

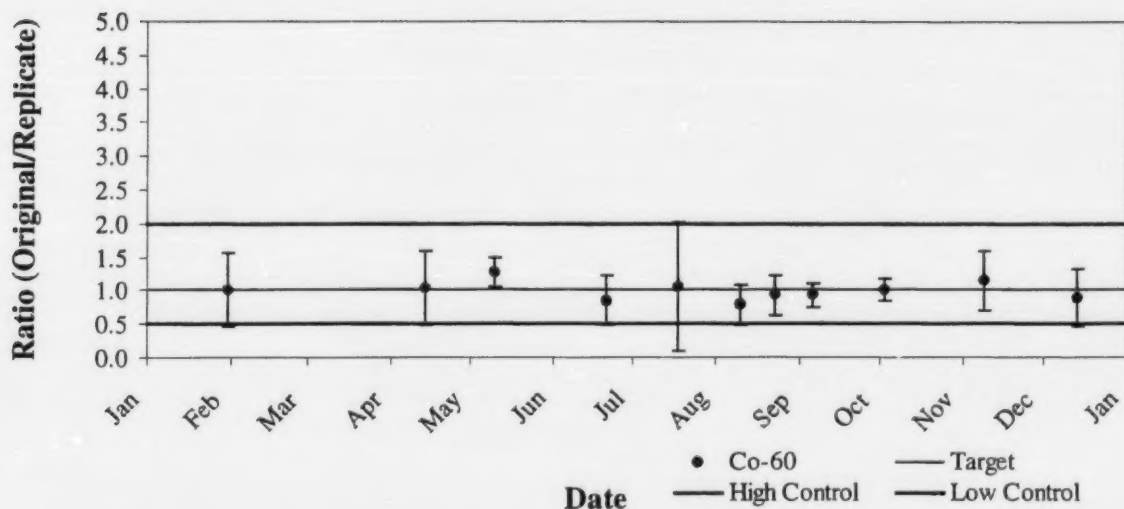


Figure 7.24: Co-60 QA Performance (Internal - Duplicate Samples or Replicate Analyses)

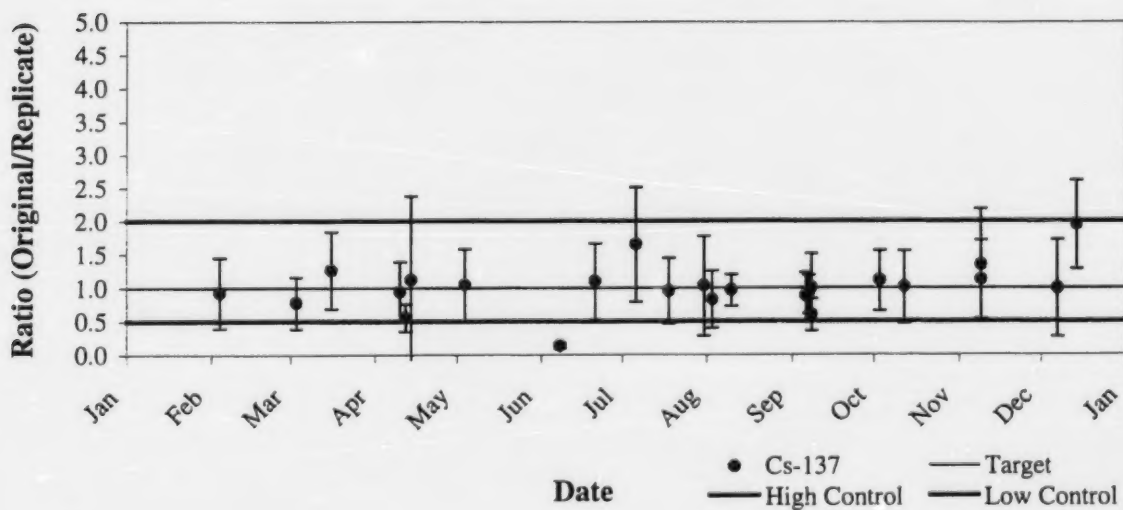


Figure 7.25: Cs-137 QA Performance (Internal - Duplicate Samples or Replicate Analyses)

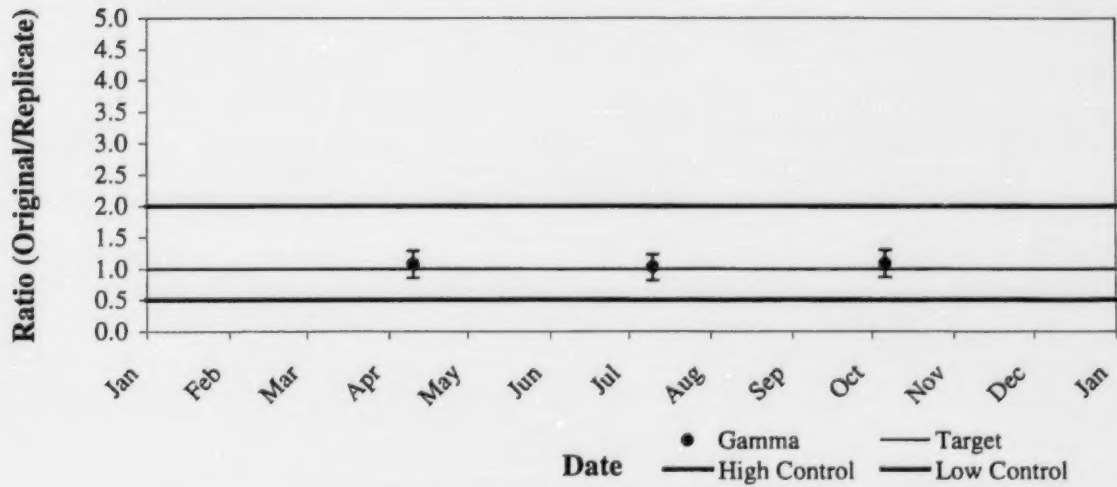


Figure 7.26: TLD QA Performance (Internal - Duplicate Samples or Replicate Analyses)

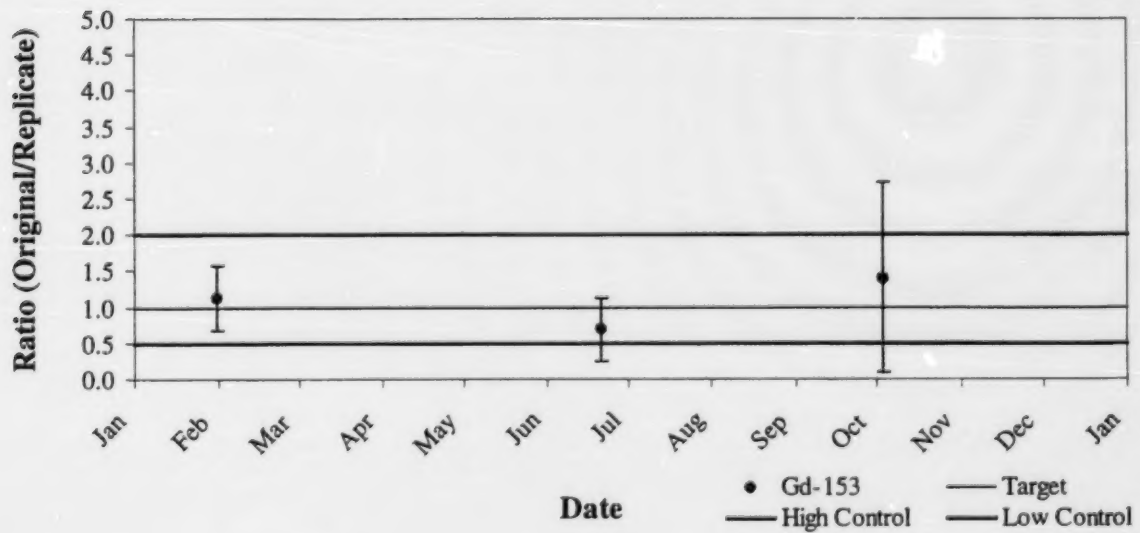


Figure 7.27: Gd-153 QA Performance (Internal - Duplicate Samples or Replicate Analyses)

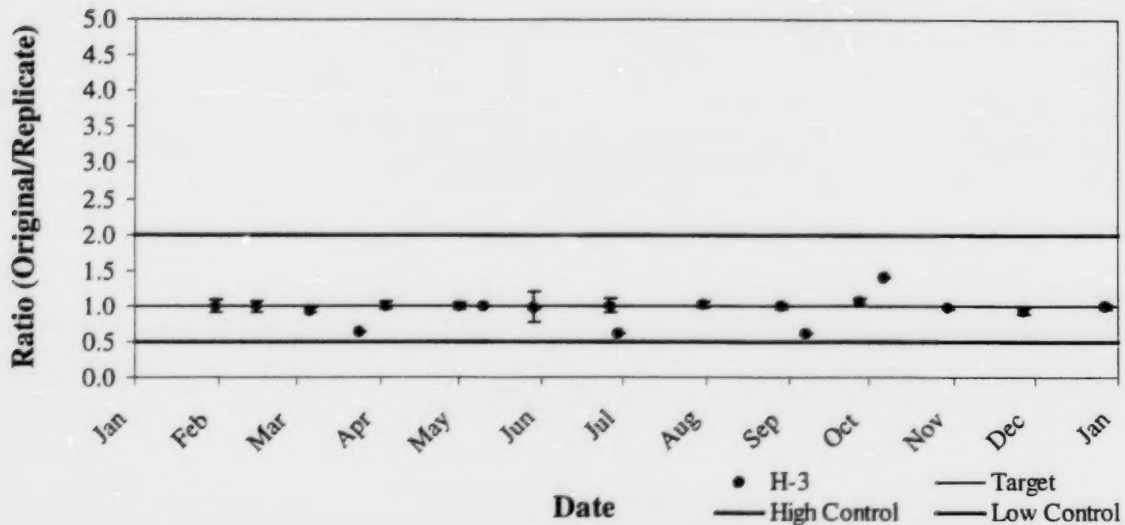


Figure 7.28: H-3 QA Performance (Internal - Duplicate Samples or Replicate Analyses)

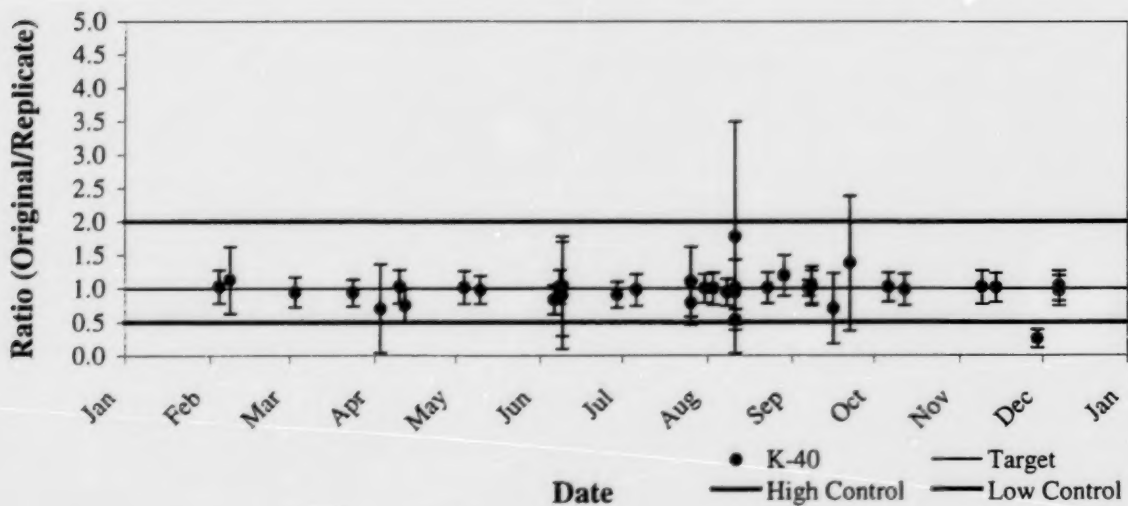


Figure 7.29: K-40 QA Performance (Internal - Duplicate Samples or Replicate Analyses)

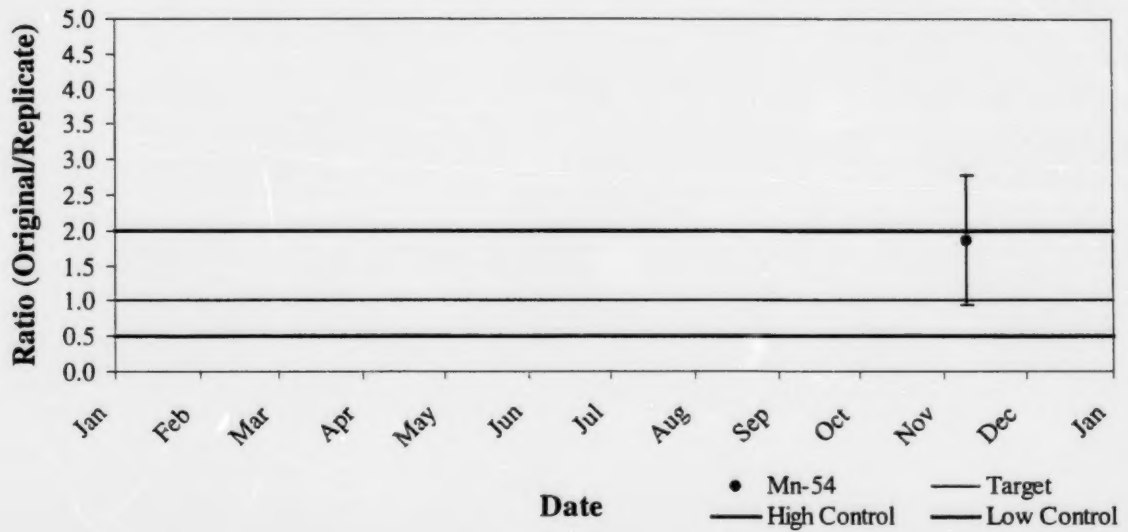


Figure 7.30: Mn-54 QA Performance (Internal - Duplicate Samples or Replicate Analyses)

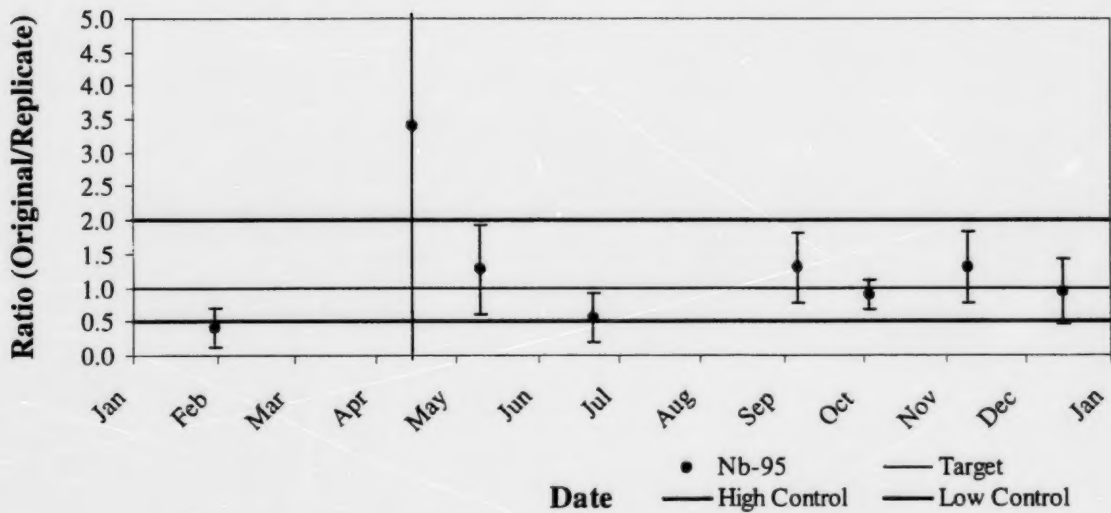


Figure 7.31: Nb-95 QA Performance (Internal - Duplicate Samples or Replicate Analyses)

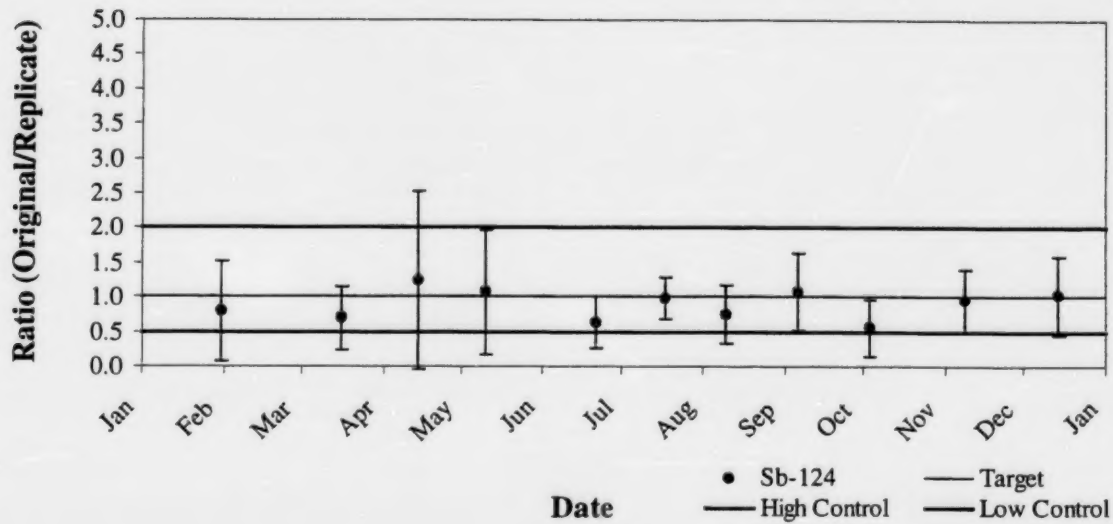


Figure 7.32: Sb-124 QA Performance (Internal - Duplicate Samples or Replicate Analyses)

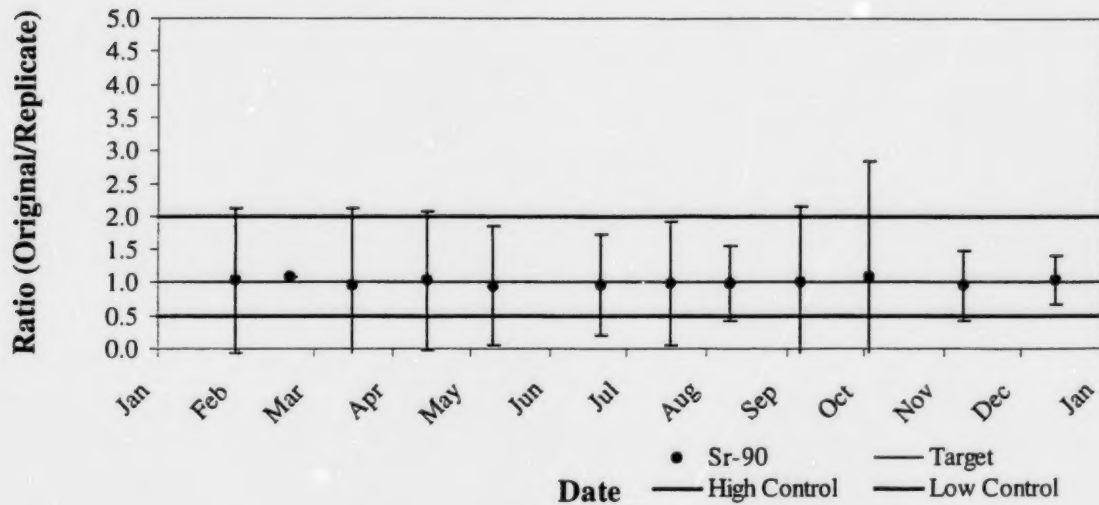


Figure 7.33: Sr-90 QA Performance (Internal - Duplicate Samples or Replicate Analyses)

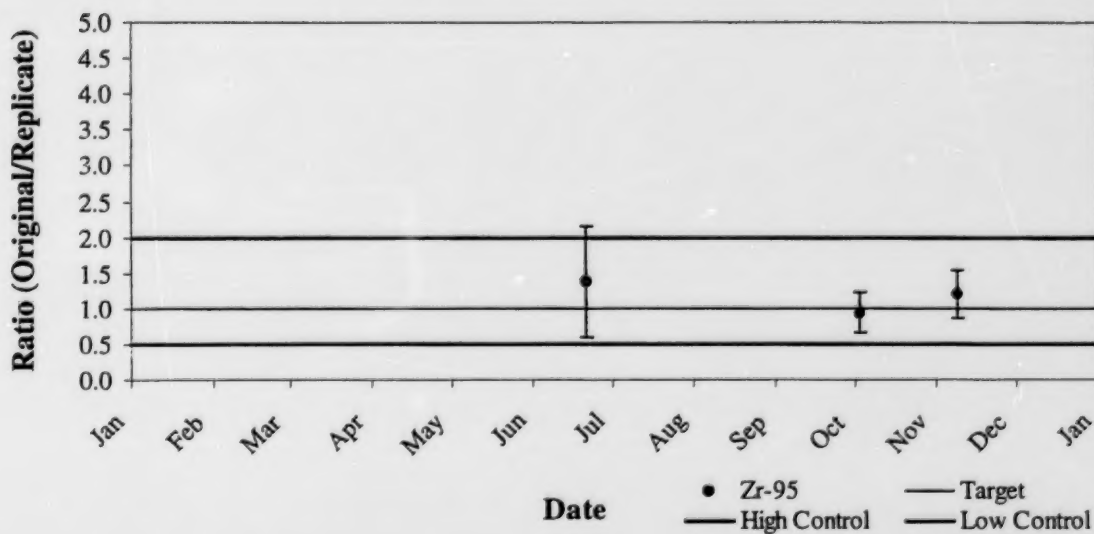


Figure 7.34: Zr-95 QA Performance (Internal - Duplicate Samples or Replicate Analyses)

The laboratory also contracted out its services in 2000 for several clients. A calibration standard was run with each set of samples to indicate to the customer the reliability of the results. These results are presented in Figures 7.20 to 7.24. As well, a stock solution of H-3 was repeatedly analysed throughout the year. The results are shown in Figure 7.25. These practices provide an extra degree of confidence in the Environmental Program.

A slightly negative bias is observed in the H-3 standard. This is due to the two to three percent difference between chemical quench and opacity quench.

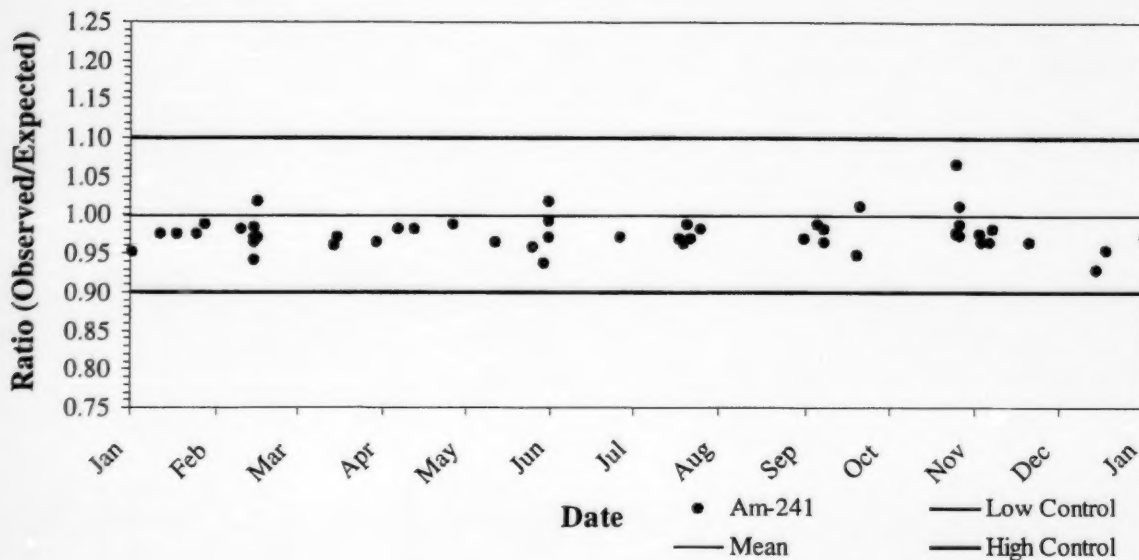


Figure 7.35: Am-241 QA Performance (Repeated Analyses of Calibration Standards)

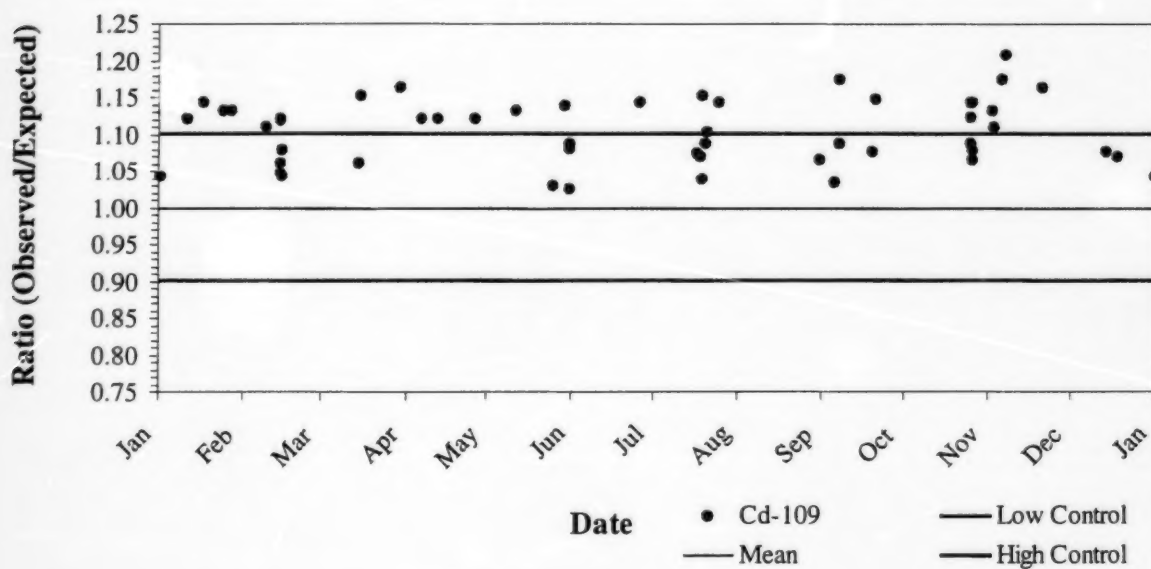


Figure 7.36: Cd-109 QA Performance (Repeated Analyses of Calibration Standards)

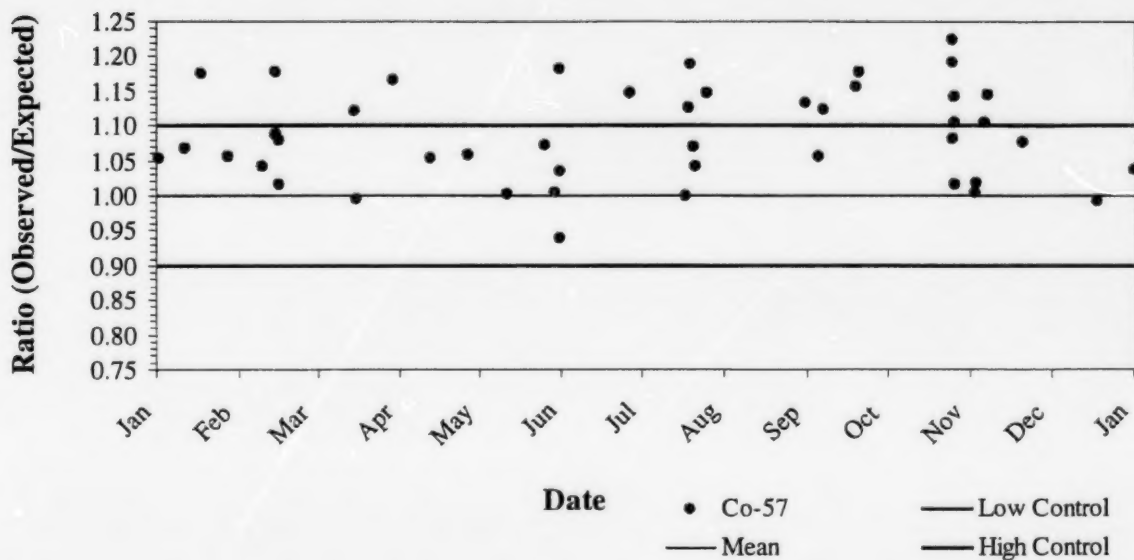


Figure 7.37: Co-57 QA Performance (Repeated Analyses of Calibration Standards)

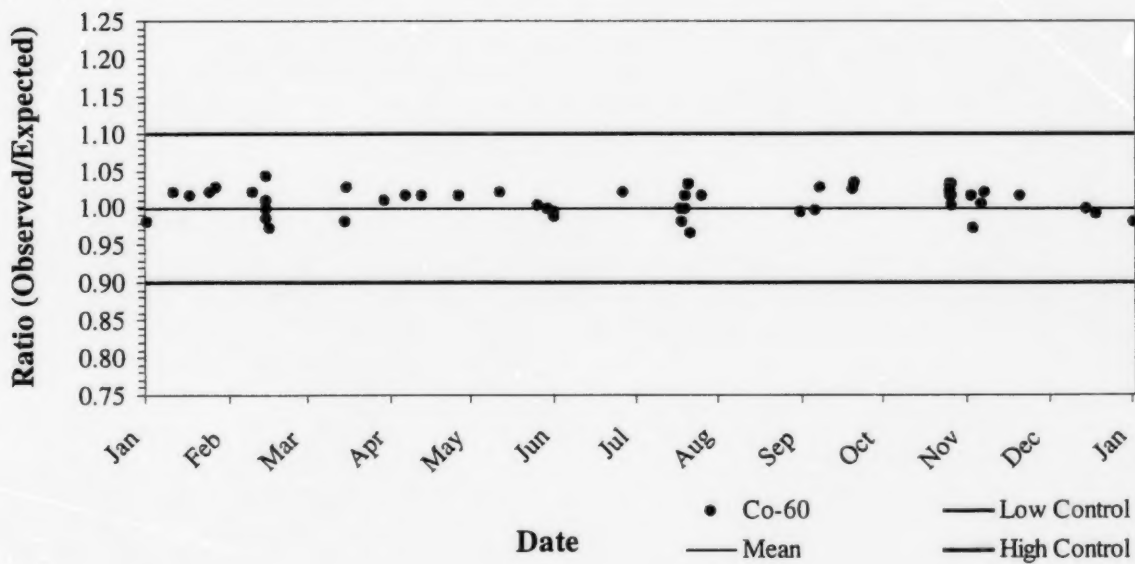


Figure 7.38: Co-60 QA Performance (Repeated Analyses of Calibration Standards)

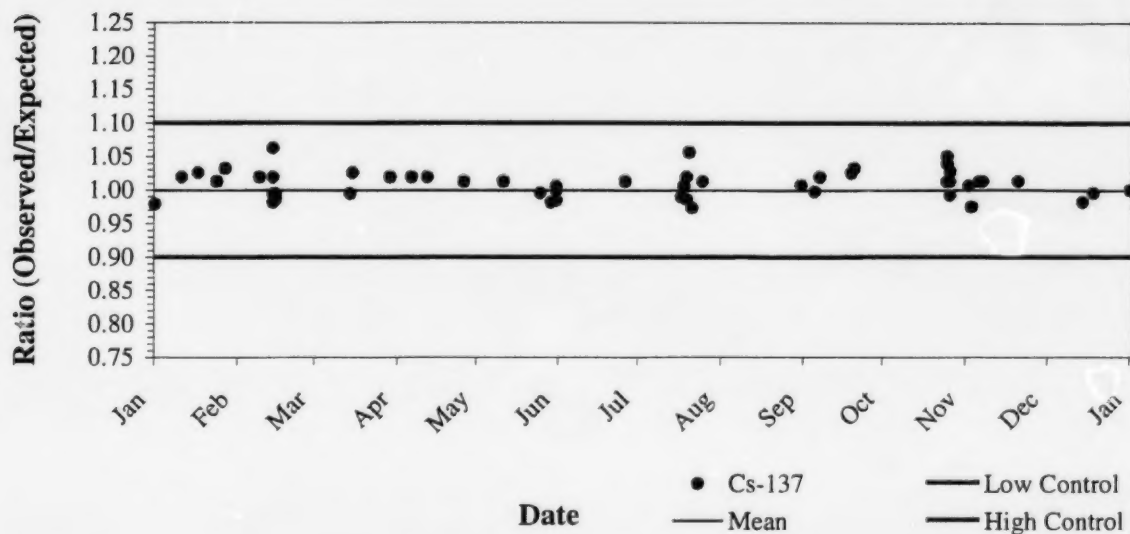


Figure 7.39: Cs-137 QA Performance (Repeated Analyses of Calibration Standards)

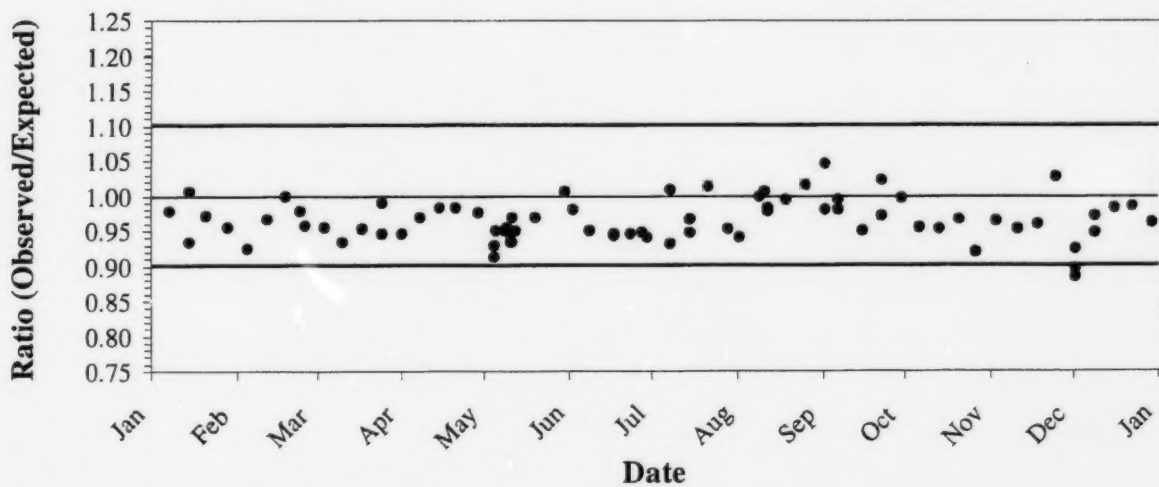


Figure 7.40: H-3 QA Performance (Repeated Analyses of Spiked Solutions)

7.04 Program Audit

The OERMP is audited every three years. The Independent Assessment Group at PLGS is the principal auditor, although other groups from within NB Power, the CNSC, or other utilities may be used.

7.04.01 Purpose and Scope

An audit was conducted by NB Power's Independent Assessment Group from August to September, 2000. The purpose of the audit was to determine if the Operational Environmental Radiation Monitoring (OERMP) performed by the Health Physics Lab in Fredericton, meets the regulatory and overall quality assurance requirements of the program. The scope of the audit included:

- Verifying procedure implementation
- Observing laboratory processing
- Reviewing identified responsibilities
- Reviewing training records
- Checking equipment calibrations
- Control of chemicals used for analysis

The audit was conducted to determine whether the objectives of the program were within the guidelines stipulated in the licensing documents. The primary features included:

- Analyses of environmental and effluent samples that permit the estimation of dose to critical groups and populations from radioactive emissions from PLGS and the SRWMF.
- Issuance of the annual report providing data to confirm compliance with release guidelines and regulations and to provide public assurance of compliance.
- Maintenance of an electronic database to facilitate the detection of trends, and maintain historical data.
- Verifying or refining environmental models used in the calculation of Derived Emission Limits (DEL) achieved by comparing the theoretical dispersion factor with one calculated empirically.
- Determining the fate of released materials to show whether any significant pathway to humans has been overlooked, and any results that are not consistent with effluent results are investigated

In addition, the following elements of the program were also considered:

- Equipment condition
- Facility upkeep
- Records management
- Human resource development
- Operating experience and communication

7.04.02 Results

The results of the audit identified three Corrective Actions, three Areas For Improvement, five Strengths, and four Recommendations. They are summarised as follows:

Corrective Actions:

1. The Operations Quality Assurance Manual does not adequately identify the policies and responsibilities for the establishment and supervision of the OERMP. Section 2.4 Environmental Protection, references supporting documentation but lacks details of the program.
2. Environmental lab procedures are in draft form.
3. Potential safety hazards during collection of samples and TLDs.

Areas for Improvement:

1. A training schedule has not been developed to ensure the required competency of personnel is achieved and maintained. Numerous courses identified in TP30.24 Rev.0 Technician Training Program Fredericton Environmental Lab have not been delivered or scheduled. Training records do not reflect all training received as evidenced by the records obtained from the corporate training coordinator and PLGS Training Department.
2. Reduction of quality assurance due to elimination of external sampling.
3. MSDS not readily available at work location (PLGS).

Strengths:

1. Professionalism, team work.
2. Records management.
3. Equipment calibration.
4. Facility upkeep and prevention of cross contamination.
5. Additional areas covered. The following program elements were also audited and are included for further recognition of commendation of performance:
 - Self-Assessments are being performed as evidenced by the reports generated for *Air Monitoring Station Modification - HPM-1999-01 (October 1999)*, *Tracking of Software Issues - HPM-1999-02 (March 2000)*. Two more self assessments are scheduled for October 2000 and March 2001 respectively. Lab personnel were not aware of the issued 1999-2000 Annual Self Assessment Report PLGS-ASAR-1999.
 - Annual reports on the Environmental Radiation Monitoring Program are being issued on a timely basis as evidenced by the distribution dates from the reports.
 - Environmental Monitoring Barns are represented pictorially with location codes, sampling media, GPS coordinates, distances and travel directions and property owners.
 - Procedure updates applicable to the Health Physics Department are received along with Bulletins and Security memos.
 - There was no backlog of outstanding work evident at the time of the audit revealing that schedules are being met.
 - Logs are maintained at the appropriate work locations to record activities such as quality control checks and calibrations.

Recommendations:

1. Tables and charts in annual reports should clarify peaks and missing data.
2. Further upgrading of air monitoring stations recommended.
3. Non confidence in OPEX communication.

7.04.03 Response

The Findings from the audit were rectified via the PICA process.

7.05 Annual Review

A major review of the program by all laboratory staff takes place each year. Generally, all aspects of the program are looked at to ensure the objectives, as stated in this document, are being met. The following is a brief discussion of this review.

7.05.01 Routine Monitoring Results

The analyses results were examined for consistency and trends using graphs and tables created for the Annual Report and using the performance indicators described in the procedures.

This aspect of the review is discussed in sections 4 and 5 of this report.

7.05.02 Procedures

Possible new or replacement methods were examined and obsolete ones were identified for deletion. Under the new program, procedures are checked every three years as are their execution by staff. Any deviations from these will be documented in future annual reports.

Procedures were revised throughout 2000 to reflect the current program and accurately describe the actual work in the laboratory. They were issued early in 2001.

7.05.03 Analytical QA Results

The analyses results were examined for consistency and trends using graphs and tables created for the Annual Report as well as the QC Failure Log book. Schedules, number of samples and problems associated with the Analytical QA Program were addressed. The degree of satisfaction with External Agencies and options for different suppliers of these samples were explored.

This aspect of the review is discussed in Sections 7.1 and 7.2 of this report.

7.05.04 Equipment

The status of laboratory and field equipment, software and facilities were considered.

Plans were made for improvements to air monitoring stations and addressing pest problems. A spare Ge detector will be set up to handle large sample loads. The PCs on the alpha/beta and LSC systems need to be upgraded. A different method of obtaining meteorological data is being investigated in response to the unreliability of the current system. Software development continues to be a vulnerability.

7.05.05 Personnel

Training during the previous year was reviewed and plans for the coming year were made from the point of view of program requirements and employee development. Human resources available to accomplish program objectives were evaluated.

Training course descriptions specific for the laboratory were issued in 2000 and training exemption forms were signed where appropriate. The work load continues to be high at all levels. A casual employee has been hired to alleviate this problem. Appropriate training will be given.

7.05.06 Safety

Laboratory and field work safety was reviewed.

Working alone in the field was an issue that needed to be better defined. Old chemicals no longer required were removed from the laboratory.

7.05.07 Emissions

The final gaseous and liquid effluent reports were studied. Their impact on routine monitoring results and their implications to the OERMP were assessed.

There were no unusual emissions for 2000 that warranted any change to the program.

7.05.08 Meteorological Data

The impact on routine monitoring results and the implications to the OERMP are assessed. The results of the Met Monitoring QA analysis were discussed.

The meteorological data comes from the daily files, containing hourly summaries, resident on the computer system at Energy Control. These files contained some corrupt data or were missing data. A solution to this problem is being sought.

7.05.09 Emergency Measures Organisation Demographic Data

When available, these data are studied for implications to the program.

The next scheduled survey will take place in 2001.

7.05.10 Appropriateness of Media, Locations and Frequency

The choice of media, and location and frequency of sampling were examined in the broader context of the past year. Possible adjustments were examined to reflect changing conditions in the Lepreau area and future plans and expectations for PLGS from the public and CNSC.

The broader mandate for the CNSC and the implications of the Priority Substance List II were considered. An action plan will be developed in 2001.

The well water, garden vegetable and bore hole sampling locations will be increased. A new location for intercepting leachate from the old landfill will be identified. The commercial sea urchin fishery will be explored for possible inclusion in the program

There are still no known cows or goats within the area of PLGS.

7.05.11 High LLDs

The report of dose to the Critical Group at the LLD for each analysis was studied.

The major radionuclides that exceed the 5 μSv level (annual average) continue to be noble gases (detection is with a TLD which measures 20 μSv dose). However the noble gas spectrometer on the GEM allows for a much smaller LLD calculation. Other exceptions are:

- Ba-140 in soil (6.5 μSv); sediment (8.5 μSv)
- Ce-144 in pond/puddle/surface water (7.5 μSv); rain water (11.5 μSv); well water (10.5 μSv); garden vegetables (7.2 μSv)
- Co-60 in rain water (5.3 μSv); garden vegetables (5.4 μSv)
- Cs-134 in garden vegetables (5.4 μSv)
- I-131 in garden vegetables (5.1 μSv)
- Ru-106 in pond/puddle/surface water (8.4 μSv); rain water (16.5 μSv); well water (10.3 μSv); garden vegetables (18.4 μSv); berries (10.6 μSv); clams (5.7 μSv); fish (6.9 μSv)

Effluent analyses show these are not a major component of release and no changes to counting protocols are warranted

7.05.12 Records

The completeness and consistency of data in the environmental records database are verified at the end of each monitoring year. A QA audit is also performed on the paper copies of analysis reports filed in the laboratory office. The changes to the database are documented below:

- Two Parshall Flume samples were mislabelled when the samples were collected at PLGS. This was determined after the results were stored. This was corrected.

- The wrong spectrum was stored for a Sediment sample. A new sample had to be collected, and the results from the incorrect spectrum removed from the database.
- Two TLDs were mislabelled. This was corrected.
- A Garden Vegetable sample had the wrong location code. This was corrected.
- The results for two Soil samples were not completely stored. This was corrected.
- Seven Beach Survey results were entered with the wrong units and two were duplicated. These were corrected.

7.05.13 Contamination

Results from routine contamination monitoring as well as equipment background checks were examined.

The only deviations from normal background identified were in LS vials and glass fibre filters (new batches had a different background than was previously observed).

7.05.14 Problem Resolution

The PICA system at PLGS was implemented to identify, track and trend conditions, concerns, and problems and solutions.

The results from the audit were put into this system.

7.05.15 Changes to Reference Document

The OERMP Reference Document was issued in January, 2000. Major changes since then are:

- gross alpha/beta counting is never done on seawater or milk samples
- Sr-89,90 analysis is performed on air filters if more than 1% DEL (GEM) is released from PLGS
- Sr-89,90 analysis is performed on seawater if more than 1% DEL (LEM) is released from PLGS
- soil is not sieved or not always heated before counting
- procedures are checked at least every three years as are their execution by staff
- I-131 is not included in any QA samples
- Sr-89,90 and Cs-137 are not included in Duplicate/Replicate filter samples
- Sr-89 is not included in most QA samples
- the major review of the program takes place in February and is approved in March
- I00G is on the north fence (west side)
- I00I is on the north fence (east side)

7.05.16 Program Improvement

Areas for improvement are identified:

- from relevant operating experience (internal & external)
- during the annual review
- during audits
- by laboratory staff
- by other HP staff
- by HP manager
- by the self assessment process

During 2000, a study of the groundwater movement on the peninsula was commissioned. The objective was to obtain recommendations for locations of additional bore holes that will better characterise groundwater near PLGS. New holes will be drilled in 2001.

Implementation of the revised OERMP and correcting of items arising from the audit were major program improvements for 2000.

Appendices

Appendix A: Statistics, Detection Limits, and Dose at Detection Limits

1 Statistics

The following statistical conventions are applied in the analysis of each sample:

- Detection limits are defined following the method described by Lochamy(12). The lower limit of detection (LLD) at the 99% confidence level is defined as $6.58 S_b$, where S_b is the standard deviation of the appropriate radiation background measurement. This LLD corresponds to that amount of activity in a sample that will yield a net count greater than $3.29 S_b$, or the so-called critical level (CL), with 99% probability. Thus, the LLD specifies the theoretical capability of the system to detect a given amount of radioactivity, whereas CL is used to determine whether an actual activity measurement should be considered detected. Any net measurement greater than $3.29 S_b$ is considered detected at the 99% confidence level. This also implies a 1% probability of stating that activity is present when it is not (false positive). If activity is present at the LLD level ($6.58 S_b$), there is a 1% probability of stating that activity is not present when it is (false negative).
- The CL of $3.29 S_b$ and LLD of $6.58 S_b$ apply in those analytical systems where the background levels are either not well defined, or where there is a relationship between the background levels and the detected signal above background, as in Ge gamma spectroscopy. Where the background readings are well defined and are independent of sample readings, as in the TLD data, the CL is $2.33 S_b$ and the LLD is $4.66 S_b$.
- In most of the tables of data (Section 3.0), it is this Critical Level that appears in column 2.
- Unless otherwise indicated, the precision of the measurements reported here is given as $\pm 1.96 S_a$ (95% confidence level), where S_a is the standard deviation of the activity measurement.
- The value and standard deviation are reported with two significant figures using modified scientific notation, for example 0.032 is expressed as 3.2E-02.

The lower limits of detection (LLD) of all radionuclides in the various sample media are shown in Tables A.01 to A.11. The Annual Dose is to a member of the Critical Group. The LLDs are based on typical data. Decay of radionuclides is accounted for in the LLD calculations except for H-3 and C-14 (long half-lives). The major assumptions are that the sample is taken at one kilometre from the point of emissions and that the level is maintained for the year. Milk is assumed to be from a cow pastured at 1.5 km, fish and lobster are caught at the CCW outlet and sediment, dulse, seawater and clams are collected at Dipper Harbour.

The CSA recommends, where technically feasible, that all measurements achieve LLDs less than that which would result in a dose of $5 \mu\text{Sv}$ to the Critical Group. Most radionuclides pass this criterion. The major exceptions are noble gases. Detection of this group is through TLD

measurements (20 μSv dose to the Critical Group at the LLD). However, the noble gas spectrometer on the gaseous effluent monitor allows for a much smaller LLD calculation. Other exceptions are Ba-140 in soil and sediment (10 to 12 μSv); Ru-106 in water and clams (7 to 17 μSv); Ce-144 in water (11 μSv); and I-131 in food (8 μSv). Effluent analyses show these are not major components of release. Part of the QA process identifies those LLDs or activities that do not meet this target.

1.01 Air

1.01.01 Airborne Particulates

Typical LLDs are given for a 2400 m^3 sample, counted for 5000 s. The LLDs are decay corrected to the midpoint between the start and end of sampling, except for the gross alpha/beta results which represent the long-lived activity present a few days after sample collection. Gross alpha/beta is for trending only.

1.01.02 Airborne Radioiodines

A typical LLD for I-131 is approximately $9\text{E-}05 \text{ Bq/m}^3$ (for a 2400 m^3 sample, counted for 50 000 s), which is decay corrected to the midpoint between the start and end of sampling.

1.01.03 Airborne Tritium

The LLD is approximately $1\text{E-}01 \text{ Bq/m}^3$ of air for a typical sample of 10 to 70 m^3 (counted for 100 min). Due to the long half-life and relatively short period of time between sampling and analysis, decay correction is not applied.

1.01.04 Airborne Carbon-14

A typical LLD is approximately $4\text{E-}02 \text{ Bq/m}^3$ of air for a 30 m^3 sample (counted for 100 min). Due to the long half-life and relatively short period of time between sampling and analysis, decay correction is not applied.

1.01.05 TLD

The LLD is about 20 μSv . For typical quarterly measurements in the region of 150-200 μSv , measurements can be made to $\pm 10\%$ at the 95% confidence level.

Table A.01 Annual Dose at the LLD for Air

Nuclide	LLD (Bq/m³)	Dose at LLD (μSv)	Activity That Gives 5 μSv (Bq/m³)
H-3	9.6E-02	4.8E-02	9.9E+00
C-14	4.0E-02	1.9E+00	1.0E-01
Cr-51	5.8E-04	3.2E-03	9.2E-01
Mn-54	7.8E-05	9.2E-02	4.3E-03
Fe-59	1.7E-04	6.1E-02	1.4E-02
Co-58	8.0E-05	3.5E-02	1.2E-02
Co-60	8.2E-05	1.7E+00	2.4E-04
Zn-65	1.9E-04	3.3E-01	2.9E-03
Kr-85	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Kr-85m	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Kr-87	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Kr-88	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Zr-95	1.3E-04	1.1E-01	6.2E-03
Nb-95	9.4E-05	9.9E-02	4.7E-03
Ru-103	7.4E-05	8.1E-03	4.5E-02
Ru-106	6.0E-04	1.0E+00	2.9E-03
Ag-110m	6.2E-05	2.2E-01	1.4E-03
I-131	8.4E-05	1.6E-01	2.5E-03
Xe-131m	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Xe-133	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Xe-133m	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Xe-135	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Xe-135m	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Xe-138	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Cs-134	6.4E-05	4.3E-01	7.4E-04
Cs-137	6.6E-05	1.6E+00	2.0E-04
Ba-140	4.8E-04	8.9E-02	2.7E-02
La-140	2.0E-04	2.5E-03	4.1E-01
Ce-141	7.6E-05	4.8E-03	7.9E-02
Ce-144	2.2E-04	2.7E-01	4.0E-03
Noble Gases	2.0E+01 μSv	2.0E+01	5.0E+00 μSv
Gross Alpha	6.6E-06		
Gross Beta	1.7E-05		

1.02 Milk

Typical LLDs for the nuclides of interest in milk (a 3.6 L sample counted for 50 000 s for gamma; 6 mL sample counted for 100 min for tritium) are listed in Table A.02 for the time of sample collection.

Table A.02 Annual Dose at the LLD for Milk

<i>Nuclide</i>	<i>LLD (Bq/L)</i>	<i>Dose at LLD (μSv)</i>	<i>Activity That Gives 5 μSv (Bq/L)</i>
H-3	2.4E+01	3.1E-01	3.9E+02
Cr-51	6.4E-01	1.0E-02	3.1E+02
Mn-54	9.2E-02	1.9E-02	2.5E+01
Fe-59	2.2E-01	2.2E-01	5.1E+00
Co-58	9.0E-02	7.5E-02	6.0E+00
Co-60	1.1E-01	9.0E-01	6.1E-01
Zn-65	2.4E-01	5.3E-01	2.3E+00
Zr-95	1.6E-01	4.3E-02	1.8E+01
Nb-95	9.2E-02	1.2E-01	3.8E+00
Ru-103	8.4E-02	1.9E-02	2.2E+01
Ru-106	7.8E-01	2.7E+00	1.4E+00
Ag-110m	8.2E-02	5.5E-02	7.4E+00
I-131	9.4E-02	1.8E+00	2.6E-01
Cs-134	7.8E-02	3.1E-01	1.3E+00
Cs-137	9.8E-02	3.1E-01	1.6E+00
Ba-140	3.4E-01	2.1E-01	8.1E+00
La-140	1.1E-01	8.9E-02	6.1E+00
Ce-141	1.2E-01	3.0E-02	2.1E+01
Ce-144	5.0E-01	9.5E-01	2.6E+00

1.03 Water

The LLDs in Table A.03 apply to the time of sample collection for a 3.6 L sample counted for 5000 s for gamma and a 6 mL sample counted for 100 min for tritium. Alpha/beta results (a 200 mL sample counted for 100 min) represent the long-lived activity present several days after sample collection.

The LLDs are based on typical data for rainwater (the only water sample that has significant decay before analysis). Since decay of radionuclides is accounted for in the LLD calculations, Well Water and other water sample types will have lower LLDs than these. The major assumptions are that the sample is taken at one kilometre from the point of emissions, that the level is maintained for the year and the sample type is the major source of drinking water. Obviously this is not the case but it gives a simple "worst case" that is easy to monitor and calculate.

Table A.03 Annual Dose at the LLD for Water

<i>Nuclide</i>	<i>LLD (Bq/L)</i>	<i>Dose at LLD (μSv)</i>	<i>Activity That Gives 5 μSv (Bq/L)</i>
H-3	2.4E+01	3.4E-01	3.6E+02
Cr-51	5.4E+01	7.4E-02	3.7E+03
Mn-54	5.0E-01	1.7E-01	1.4E+01
Fe-59	1.3E+00	9.1E-01	7.1E+00
Co-58	5.6E-01	3.7E-01	7.5E+00
Co-60	4.6E-01	4.5E+00	5.1E-01
Zn-65	1.1E+00	2.3E+00	2.4E+00
Zr-95	9.8E-01	4.0E-01	1.2E+01
Nb-95	6.8E-01	4.0E-01	8.5E+00
Ru-103	6.4E-01	1.8E-01	1.8E+01
Ru-106	4.6E+00	1.7E+01	1.4E+00
Ag-110m	4.6E-01	6.2E-01	3.7E+00
I-131	2.4E+00	3.9E+00	3.1E+00
Cs-134	4.4E-01	4.8E+00	4.6E-01
Cs-137	5.2E-01	3.9E+00	6.6E-01
Ba-140	5.4E+00	2.7E+00	1.0E+01
La-140	2.2E+00	9.1E-01	1.2E+01
Ce-141	8.4E-01	3.4E-01	1.2E+01
Ce-144	2.4E+00	1.1E+01	1.1E+00
Gross Alpha	1.2E-01		
Gross Beta	8.4E-02		

1.04 Food

The LLDs in Table A.04 apply to the time of sample collection. Samples are counted for 5000 s (size varies). The LLDs are based on typical data for garden vegetables. Garden vegetables have significant radioactive decay before analysis (the local residents harvest them and store them in their freezers for varying lengths of time). Since decay of radionuclides is accounted for in the LLD calculations, berries and other food sample types (which experience less radioactive decay) will have lower LLDs than these.

Table A.04 Annual Dose at the LLD for Food

<i>Nuclide</i>	<i>LLD (Bq/kg)</i>	<i>Dose at LLD (μSv)</i>	<i>Activity That Gives 5 μSv (Bq/kg)</i>
Cr-51	3.0E+01	5.9E-02	2.5E+03
Mn-54	3.4E+00	1.3E-01	1.3E+02
Fe-59	7.8E+00	8.4E-01	4.6E+01
Co-58	3.6E+00	3.0E-01	6.0E+01
Co-60	3.8E+00	3.9E+00	4.9E+00
Zn-65	9.0E+00	2.2E+00	2.1E+01
Zr-95	6.2E+00	3.3E-01	9.4E+01
Nb-95	4.0E+00	3.6E-01	5.6E+01
Ru-103	3.8E+00	1.7E-01	1.1E+02
Ru-106	3.0E+01	1.3E+01	1.1E+01
Ag-110m	3.0E+00	4.7E-01	3.2E+01
I-131	1.0E+01	6.9E+00	7.6E+00
Cs-134	3.0E+00	3.6E+00	4.2E+00
Cs-137	3.4E+00	2.9E+00	6.0E+00
Ba-140	2.4E+01	3.5E+00	3.5E+01
La-140	9.4E+00	1.2E+00	4.0E+01
Ce-141	4.2E+00	1.9E-01	1.1E+02
Ce-144	1.4E+01	4.9E+00	1.4E+01

1.05 Soil

The LLDs in Table A.05 apply to the time of sample collection. Samples of approximately 200 g are counted for 5000 s.

Table A.05 Annual Dose at the LLD for Soil

<i>Nuclide</i>	<i>LLD (Bq/kg)</i>	<i>Dose at LLD (μSv)</i>	<i>Activity That Gives 5 μSv (Bq/kg)</i>
Cr-51	4.0E+01	2.5E-01	7.9E+02
Mn-54	5.8E+00	1.2E+00	2.5E+01
Fe-59	1.2E+01	3.1E+00	1.9E+01
Co-58	5.0E+00	1.1E+00	2.2E+01
Co-60	5.8E+00	3.2E+00	9.1E+00
Zn-65	1.3E+01	1.7E+00	3.9E+01
Zr-95	1.0E+01	5.1E+00	9.9E+00
Nb-95	6.0E+00	9.9E-01	3.0E+01
Ru-103	4.8E+00	5.1E-01	4.7E+01
Ru-106	4.6E+01	1.9E+00	1.2E+02
Ag-110m	5.2E+00	2.7E+00	9.7E+00
I-131	6.8E+00	5.2E-01	6.6E+01
Cs-134	5.2E+00	1.5E+00	1.7E+01
Cs-137	5.6E+00	7.1E-01	3.9E+01
Ba-140	2.2E+01	1.1E+01	9.6E+00
La-140	7.2E+00	*	*
Ce-141	6.8E+00	1.2E-01	2.8E+02
Ce-144	2.4E+01	2.9E-01	4.2E+02
TLD	2.0E+01 μ Sv	2.0E+01	5.0E+00 μ Sv
*Dose for Ba-140 assumes equilibrium with La-140 (contribution from both)			

1.06 Seawater

The LLDs in Table A.06 apply to the time of sample collection (for a 3.6 L sample counted for 5000 s for gamma; a 6 mL sampled counted for 100 min for tritium). The dose is small due to the simple facts that the Bay of Fundy is frigid at the best of times (occupancy factor is low) and no one drinks salt water.

Table A.06 Annual Dose at the LLD for Seawater

<i>Nuclide</i>	<i>LLD (Bq/L)</i>	<i>Dose at LLD (μSv)</i>	<i>Activity That Gives 5 μSv (Bq/L)</i>
H-3	2.4E+01	9.2E-11	1.3E+12
Cr-51	2.2E+00	2.6E-10	4.3E+10
Mn-54	2.8E-01	7.9E-10	1.8E+09
Fe-59	6.2E-01	2.6E-09	1.2E+09
Co-58	2.8E-01	9.1E-10	1.5E+09
Co-60	3.2E-01	2.4E-09	6.8E+08
Zn-65	6.8E-01	1.3E-09	2.6E+09
Zr-95	5.2E-01	1.2E-09	2.2E+09
Nb-95	3.0E-01	9.3E-10	1.6E+09
Ru-103	2.8E-01	4.4E-10	3.2E+09
Ru-106	2.6E+00	1.6E-09	8.3E+09
Ag-110m	2.6E-01	2.3E-09	5.7E+08
I-131	3.6E-01	2.3E-09	8.0E+08
Cs-134	2.6E-01	1.3E-09	1.0E+09
Cs-137	3.0E-01	5.2E-10	2.9E+09
Ba-140	1.2E+00	2.6E-08	2.4E+08
La-140	4.6E-01	*	*
Ce-141	4.0E-01	1.1E-10	1.8E+10
Ce-144	1.6E+00	2.7E-10	3.0E+10
* Dose for Ba-140 assumes equilibrium with La-140 (contribution from both)			

1.07 Clams

Typical LLDs are given in Table A.07 for the edible portions of clams, decay corrected to the time of sample collection. Samples are counted for 5000 s (size varies). The major assumptions are that the sample is taken at Dipper Harbour and that the level is maintained for the year.

Table A.07 Annual Dose at the LLD for Clams

<i>Nuclide</i>	<i>LLD (Bq/kg)</i>	<i>Dose at LLD (μSv)</i>	<i>Activity That Gives 5 μSv (Bq/kg)</i>
Cr-51	5.0E+01	2.0E-02	1.3E+04
Mn-54	7.0E+00	6.5E-02	5.4E+02
Fe-59	1.4E+01	3.1E-01	2.3E+02
Co-58	7.2E+00	1.3E-01	2.7E+02
Co-60	6.4E+00	1.8E+00	1.8E+01
Zn-65	1.4E+01	8.8E-01	7.8E+01
Zr-95	1.2E+01	1.5E-01	3.7E+02
Nb-95	6.6E+00	1.4E-01	2.3E+02
Ru-103	6.0E+00	5.5E-02	5.5E+02
Ru-106	5.8E+01	6.5E+00	4.5E+01
Ag-110m	5.8E+00	2.2E-01	1.3E+02
I-131	7.2E+00	9.5E-01	3.8E+01
Cs-134	6.6E+00	1.6E+00	2.1E+01
Cs-137	6.8E+00	1.5E+00	2.2E+01
Ba-140	2.4E+01	7.7E-01	1.6E+02
La-140	9.4E+00	2.2E-01	2.1E+02
Ce-141	7.4E+00	8.0E-02	4.6E+02
Ce-144	3.2E+01	2.6E+00	6.3E+01

1.08 Fish

Typical LLDs are given in Table A.08 for the edible portions of fish, decay corrected to the time of sample collection. Samples are counted for 5000 s (size varies).

Table A.08 Annual Dose at the LLD for Fish

<i>Nuclide</i>	<i>LLD (Bq/kg)</i>	<i>Dose at LLD (μSv)</i>	<i>Activity That Gives 5 μSv (Bq/kg)</i>
Cr-51	1.3E+01	1.6E-02	4.0E+03
Mn-54	1.5E+00	5.1E-02	1.5E+02
Fe-59	3.8E+00	2.8E-01	6.8E+01
Co-58	1.5E+00	9.2E-02	8.0E+01
Co-60	1.4E+00	1.3E+00	5.4E+00
Zn-65	3.0E+00	7.0E-01	2.2E+01
Zr-95	2.2E+00	1.1E-01	1.0E+02
Nb-95	1.4E+00	1.1E-01	6.6E+01
Ru-103	1.5E+00	4.9E-02	1.5E+02
Ru-106	1.1E+01	4.4E+00	1.2E+01
Ag-110m	1.2E+00	1.7E-01	3.5E+01
I-131	7.8E+00	1.3E+00	3.1E+01
Cs-134	1.0E+00	1.2E+00	4.5E+00
Cs-137	1.4E+00	1.0E+00	7.1E+00
Ba-140	1.0E+01	7.8E-01	6.4E+01
La-140	4.6E+00	2.4E-01	9.6E+01
Ce-141	1.8E+00	6.0E-02	1.5E+02
Ce-144	5.8E+00	1.6E+00	1.8E+01

1.09 Lobster

Typical LLDs are given in Table A.09 for the edible portions of lobster decay corrected to the time of sample collection. Samples are counted for 5000 s (size varies).

Table A.09 Annual Dose at the LLD for Lobster

<i>Nuclide</i>	<i>LLD (Bq/kg)</i>	<i>Dose at LLD (μSv)</i>	<i>Activity That Gives 5 μSv (Bq/kg)</i>
Cr-51	3.0E+01	1.3E-02	1.2E+04
Mn-54	2.8E+00	2.1E-02	6.7E+02
Fe-59	9.0E+00	1.5E-01	2.9E+02
Co-58	3.2E+00	6.7E-02	2.4E+02
Co-60	3.8E+00	5.4E-01	3.5E+01
Zn-65	7.8E+00	3.4E-01	1.2E+02
Zr-95	5.4E+00	6.8E-02	4.0E+02
Nb-95	4.4E+00	9.0E-02	2.4E+02
Ru-103	4.0E+00	3.1E-02	6.4E+02
Ru-106	3.0E+01	2.4E+00	6.3E+01
Ag-110m	3.4E+00	8.8E-02	1.9E+02
I-131	1.7E+01	3.3E+00	2.6E+01
Cs-134	2.8E+00	6.4E-01	2.2E+01
Cs-137	3.4E+00	4.5E-01	3.8E+01
Ba-140	3.4E+01	1.2E+00	1.4E+02
La-140	1.2E+01	4.2E-01	1.4E+02
Ce-141	4.4E+00	4.3E-02	5.1E+02
Ce-144	1.3E+01	8.7E-01	7.4E+01

1.10 Dulse

Typical LLDs are given in Table A.10 for dulse, decay corrected to the time of sample collection. Samples are counted for 5000 s (size varies). The major assumptions are that the sample is taken at Dipper Harbour and that the level is maintained for the year.

Table A.10 Annual Dose at the LLD for Dulse

<i>Nuclide</i>	<i>LLD (Bq/kg)</i>	<i>Dose at LLD (μSv)</i>	<i>Activity That Gives 5 μSv (Bq/kg)</i>
Cr-51	2.0E+01	2.4E-03	4.2E+04
Mn-54	3.4E+00	7.4E-03	2.3E+03
Fe-59	8.0E+00	4.4E-02	9.0E+02
Co-58	3.4E+00	1.5E-02	1.1E+03
Co-60	3.4E+00	2.1E-01	7.9E+01
Zn-65	8.2E+00	1.1E-01	3.9E+02
Zr-95	6.6E+00	1.6E-02	2.1E+03
Nb-95	3.6E+00	1.9E-02	9.5E+02
Ru-103	2.8E+00	7.1E-03	2.0E+03
Ru-106	2.6E+01	6.7E-01	2.0E+02
Ag-110m	3.0E+00	2.3E-02	6.4E+02
I-131	5.4E+00	3.0E-01	9.1E+01
Cs-134	2.8E+00	1.9E-01	7.3E+01
Cs-137	3.2E+00	1.3E-01	1.2E+02
Ba-140	1.6E+01	1.6E-01	4.9E+02
La-140	5.4E+00	2.8E-02	9.7E+02
Ce-141	3.4E+00	8.8E-03	1.9E+03
Ce-144	1.4E+01	2.4E-01	2.9E+02

1.11 Sediment

The LLDs in Table A.11 apply to the time of sample collection. Samples weighing approximately 200 g are counted for 5000 s. The major assumptions are that the sample is taken at Dipper Harbour and that the level is maintained for the year.

Table A.11 Annual Dose at the LLD for Sediment

<i>Nuclide</i>	<i>LLD (Bq/kg)</i>	<i>Dose at LLD (μSv)</i>	<i>Activity That Gives 5 μSv (Bq/kg)</i>
Cr-51	1.7E+01	2.1E-01	4.2E+02
Mn-54	2.8E+00	7.9E-01	1.8E+01
Fe-59	6.2E+00	2.3E+00	1.3E+01
Co-58	2.6E+00	8.4E-01	1.5E+01
Co-60	2.8E+00	2.3E+00	6.1E+00
Zn-65	6.8E+00	1.3E+00	2.7E+01
Zr-95	4.8E+00	3.9E+00	6.1E+00
Nb-95	3.0E+00	7.2E-01	2.1E+01
Ru-103	2.4E+00	3.9E-01	3.1E+01
Ru-106	2.0E+01	1.5E+00	6.6E+01
Ag-110m	2.2E+00	2.1E+00	5.3E+00
I-131	3.4E+00	4.7E-01	3.6E+01
Cs-134	2.0E+00	1.2E+00	8.7E+00
Cs-137	2.8E+00	6.2E-01	2.3E+01
Ba-140	1.2E+01	1.0E+01	5.8E+00
La-140	3.8E+00	*	*
Ce-141	3.0E+00	8.9E-02	1.7E+02
Ce-144	1.1E+01	2.1E-01	2.7E+02
gamma meter	0.01 μ Sv/h	3.0E+00	1.7E-02
* Dose for Ba-140 assumes equilibrium with La-140 (contribution from both)			

Appendix B: Sample Collection and Analytical Techniques

1 Analytical Techniques

All environmental samples are analysed at the Health Physics Environmental Laboratory in Fredericton. The following pages provide a general summary of the analytical techniques used in the laboratory. Sample collection, preparation and analysis are briefly described, but can be found in detail in the laboratory procedures.

The major analytical techniques and the instruments used in routine environmental analyses are summarised in the Table B.01.

Table B.01 Summary of Analytical Techniques

Analytical Technique	Instrumentation
Gamma Spectroscopy	Canberra 24% efficient* intrinsic, Ge detector in an Applied Physical Technology 10 cm graded lead cave; Canberra S-100 MCA
Liquid Scintillation (tritium and C-14)	Beckman LS-6000TA Liquid Scintillation Counter
Gross Alpha/Beta (Wet Chemical Analysis for Sr-89 and Sr-90)	Tennelec LB-5100 Alpha/Beta Counting System
Gamma Surveys	Eberline Model FH 40G-10 low range gamma survey meter (range 10 nSv/h to 1 Sv/h for 30 keV to 3 MeV photons).
Thermoluminescent Dosimetry	Panasonic UD-710A Automatic TLD Reader and UD-814A1 (CaSO ₄) dosimeters

*relative to a 3x3 inch sodium iodide detector

In gamma spectroscopy analysis, all significant peaks in the spectrum are identified either by reference to a database library of about 150 radionuclides, or by manual reference to compilations of all known radionuclides. In addition, approximately 20 selected radionuclides are specifically searched for in every sample with the exception of Air Iodine samples in which only I-131 is selected. The selected radionuclides include those that are produced in PLGS, and which would be readily detectable because of their abundance (high fission yield) and high branching ratios for gamma emissions. Naturally occurring gamma emitters, with the exception of Be-7, K-40 and Ac-228, are not included in this report. These excepted radionuclides are sometimes useful as general indicators of the consistency of the analytical techniques.

The peak search and analysis program SAMPO is used to process spectra. The library of radionuclides uses data of the Oak Ridge Laboratory. There are three categories of radionuclides evaluated:

- 1) selected nuclides of key fission and activation products
- 2) all other identified radionuclides, including natural radionuclides
- 3) detected energy peaks for which no identification can be readily made.

The three categories cover all possible eventualities in a spectral analysis and ensure that no significant radionuclides or photon energies will be overlooked.

The usefulness of gross alpha/beta analysis lies primarily in screening samples (to determine whether more detailed analyses should be performed) and showing trends. The reported alpha and beta values are assessed with respect to Am-241 and Sr-Y-90 calibration sources, respectively.

Wet chemical analysis for Sr-89,90 on Gaseous Effluent Monitoring (GEM) and Liquid Effluent Monitoring (LEM) samples follow the American Society for Testing and Materials procedure (using column chromatography).

Liquid samples, other than milk, are acidified upon receipt to keep radionuclides from plating out on the container walls. Perishable samples are refrigerated or frozen.

2 Sample Collection and Analysis

2.01 Airborne Particulates

Airborne particulates are collected on a 47 mm diameter Gelman Type A glass fibre filter, through which air is drawn at about 60 L/min (approximately 2400 m³ for a 28 day continuous sample). The volume of air sampled is measured with an in-line integrating dry gas meter. Every month the filters are replaced and the used ones are returned to the laboratory for analysis. Sampling is therefore continuous throughout the year, the only interruption (other than power failure or pump breakdown) being the few minutes for a filter change.

Air particulate filters are analysed by gamma spectroscopy as soon as possible after collection to minimise loss of information through radioactive decay (ensure detection of any short lived gamma emitters that may be present, and to minimise any decay corrections). Samples are counted for 5000 s on the Ge detector.

Approximately three days after the end of the sample collection interval, each filter is counted for 100 minutes for the simultaneous determination of gross alpha and gross beta activities. Counting is delayed to allow for the decay of the short-lived radon progeny that would otherwise complicate the analysis.

If significant alpha/beta levels are detected (twice the normal level), further investigation is initiated (longer gamma counts or radiostrontium determinations).

If significant levels of Sr-89,90 (indicating 1% of Weekly DEL) are detected in the chemical analysis of Gaseous Effluent Monitor (GEM) filters, then the air monitoring station particulate filters are also to be analysed for these radionuclides.

2.02 Airborne Radioiodine

Airborne radioiodine is collected in an activated charcoal cartridge placed downstream of the particulate filter. The cartridges are Nuclear Consulting Services NUSORB® (47 mm diameter and 48 mm length), containing 5% TEDA by weight. For a 28 day continuous sample approximately 2400 m³ of air is sampled at a flow rate of about 60 L/min. The volume of air sampled is measured with an in-line integrating dry gas meter.

Iodine-131 is the major nuclide of interest on the charcoal cartridges. The cartridges are counted in groups of four for 50 000 s on the gamma spectrometer. Counts are performed as soon as possible after collection because of the relatively short-half life of I-131 (8 days). If radioiodine is detected, then the cartridges are re-analysed individually. Other fission product radioiodines, with much shorter half-lives (minutes to hours), decay before they reach the sample location or during the time the sample is being collected. If a significant release of radioiodine were noted from the station in this interval, the samples would be changed and analysed earlier to minimize errors from decay corrections.

2.03 Airborne Tritium

A fraction of the flow in the air monitoring sample station is diverted through a molecular sieve container (Linde type 13X sieve material), to extract water vapour from the sampled air. Sample volume is measured with an in-line integrating dry gas meter.

Sampling is continuous at each location throughout the year, but is interrupted for a few minutes every month to exchange sieve containers. Since the amount of water absorbed by the molecular sieve from a given volume of air depends upon absolute humidity, flow rates are adjusted seasonally (using a Dwyer flow meter) to avoid saturation of the sieve material and to ensure adequate sample collection.

For tritium analysis by liquid scintillation counting, 6 mL of water taken from the molecular sieve condensate is counted for 100 minutes.

2.04 Airborne Carbon-14

An aquarium pump bubbles air through 2N NaOH (1 L), into which carbon dioxide from the air is absorbed. Any C-14 as CO₂ is also absorbed.

Carbon dioxide, in the form of sodium carbonate, is regenerated by acidification and analysed for the determination of C-14 activity. The carbon dioxide is passed through a silica gel trap to remove moisture and tritium and then absorbed into the chemical Carbo-sorb[®] E until saturation is reached. After the addition of the scintillation cocktail Permafluor[®] E⁺, the sample is analysed for 100 minutes by liquid scintillation counting.

2.05 Environmental Gamma Radiation (TLD)

The environmental thermoluminescent dosimeter is composed of one element of natural lithium borate with no extra filtration, and three elements of calcium sulphate with lead filtration of about 700 mg/cm². The badge is sealed in plastic, placed in a screw cap plastic container and suspended about 1 m above the ground for a period of three months. This will measure the ambient gamma dose, whether it is from activity in the air, from the ground or cosmic in origin.

Readout is by the Panasonic UD-710A Automatic Reader. For typical quarterly measurements in the region of 150-200 μ Sv, measurements can be made to $\pm 10\%$ at the 95% confidence level.

2.06 Soil

Soil samples are collected in undisturbed locations away from nearby buildings or trees. Level areas with some vegetation are preferred. A representative sample (approximately 1.6 kg) of the top 25 mm of a 20 cm by 20 cm area of soil is placed in a disposable polyethylene container.

The soil is dried on a disposable aluminum tray (at 80 °C) and sifted through a 0.5 mm sieve in the laboratory (a 1 mm sieve is used for coarse soils). Approximately 0.25 kg of dry soil is counted by gamma spectroscopy for 5000 s.

2.07 Food

Garden produce and berries, which are either collected or purchased, require no special preparation. The edible portion is put in a calibrated container and weighed (size varies). This is counted by gamma spectroscopy for 5000 s.

2.08 Milk

A 4L sample is purchased and placed in a clean polyethylene container.

For gamma spectroscopy, a 3.6 L aliquot is measured into a marinelli beaker. The remainder is distilled, and a 6 mL aliquot is analysed by liquid scintillation counting for 100 minutes. Count times are 50 000 s for gamma spectroscopy and 100 min for tritium analysis.

2.09 Water

A 4L sample of well water, pond water, lake water or surface runoff is collected in a clean polyethylene container.

A portion is removed for tritium analysis, and the remainder is acidified (15 mL of 70% nitric acid per 4 L sample). Of this, 3.6 L is measured into a marinelli beaker for gamma spectroscopy. After gamma analysis, well water samples (125-500 mL, depending upon the dissolved solids content) are evaporated to dryness on stainless steel planchets for gross alpha/beta analysis. For tritium analysis by liquid scintillation techniques, a 6 mL aliquot is analysed by liquid scintillation counting. For gamma spectroscopy, the sample is counted for 5000 s. For tritium and gross alpha/beta analyses, samples are counted for 100 min. A level twice the normal level for alpha/beta will initiate further investigation (longer gamma counts and/or Sr-89/90 analyses).

Measurements of gross alpha and beta are made about two weeks after sample collection. This delay avoids analytical interference from radon progeny whose activity is tied to that of the parent, which decays with a half-life of about 3.8 days. Natural radon and radon progeny occur in well waters everywhere and are known to reach high concentrations in many New Brunswick locations.

2.10 Vegetation

The only vegetation types routinely collected and analysed are tree lichen (Spanish moss) and various ground mosses such as *Cladonia* and *Lycopodium*. They concentrate a wide range of radionuclides, both natural and man-made. This makes them sensitive indicators of radionuclides in the environment even though they are not identified in the pathway to man.

About 25 g or more of each of the samples is collected and air-dried before analysis. No special preparation is required. The sample is placed in a calibrated container and weighed. This is counted by gamma spectroscopy for 5000 s.

2.11 Precipitation

Rain is collected continuously during the milder months.

A portion is removed for tritium analysis, and the remainder is acidified (15 mL of 70% nitric acid per 4 L sample). Of this, 3.6 L is measured into a marinelli beaker for gamma spectroscopy. For tritium analysis by liquid scintillation techniques, a 6 mL sample of water is counted for 100 min. For gamma spectroscopy, the sample is counted for 5000 s.

2.12 Sediment and Beach Surveys

Beach sediment samples are collected near the low tide mark, with preference being given to the top 10 mm of the fine sediment characteristic of tidal mud flats. A disposable polyethylene container is used to collect about 1 kg of sample. In addition, direct gamma radiation dose rate measurements are made at each sediment site using an Eberline Model FH 40G-10 low range gamma survey meter (range 10 nSv/h to 1 Sv/h for 30 keV to 3 MeV photons). The meter is held for one minute at a point one metre from the inter-tidal surface. After the sediment sample has been collected, this is repeated.

The sample is transferred to a disposable aluminum tray for drying at 80 °C. Dried, caked samples are broken into their original free granular form with a porcelain mortar and pestle, and sieved through a 0.5 mm mesh to collect the fines for analysis (a 1 mm sieve is used for coarse sediments). Approximately 0.25 kg of dried sediment is counted by gamma spectroscopy for 5000 s.

2.13 Seafood

The inshore fishery throughout the Maritimes has declined since the OERMP was started in 1982. Some of it has been closed to any kind of harvesting. However, species of local seafood are collected when available from local fishermen. Sampling focuses on fish, lobsters and clams. Some of the areas where clam harvesting is prohibited are sampled with the permission of the Department of Fisheries and Ocean. Other seafood species are more mobile and can sometimes be found throughout the area: crab, periwinkles, aquaculture salmon, scallops, herring, mackerel, dogfish, cod, haddock, sea urchin, mussels, and flounder. The severe restrictions placed on the inshore fishery as well as the depletion of stocks make many of these samples unavailable most of the time (sometimes spanning years). However, whenever they are available an effort is made to collect as many samples as possible. Approximately 0.5 kg of fresh seafood is collected per sample.

Approximately 0.25 kg of each sample is prepared for gamma spectroscopy. Lobsters are cooked first, and the edible meat is removed for analysis. Clams, periwinkles, and crab are analysed whole, with a yield factor applied to account for the mass of the inedible shell. The edible portion of fish is analysed. Samples are counted for 5000 s.

2.14 Aquatic Plants

Dulse (*Rhodomenia palmata*), an edible seaweed which is commercially harvested in the area, is collected monthly when available. Other species of seaweed concentrate a wide range of radionuclides, both natural and man-made. This makes them sensitive indicators of radionuclides in the environment even though they are not identified in the pathway to man.

A portion of the seaweed or dulse is put in a calibrated container and weighed (size varies). This is counted by gamma spectroscopy for 5000 s.

2.15 Seawater

A 4L sample is collected in a clean polyethylene container.

A portion is removed for tritium analysis, and the remainder is acidified (15 mL of 70% nitric acid per 4 L sample). Of this, 3.6 L is measured into a marinelli beaker for gamma spectroscopy. For tritium analysis by liquid scintillation techniques, a 6 mL sample of water is counted for 100 min. For gamma spectroscopy, the sample is counted for 5000 s.

If significant levels of Sr-89,90 (indicating 1% of Monthly DEL) are detected in the chemical analysis of the LEM composite, then the seawater is also to be analysed for these radionuclides.

2.16 Miscellaneous Samples

This category encompasses all of those samples collected that do not fall within the other categories. It is a mechanism by which the lab can track and evaluate media for potential inclusion in the program. It gives the program flexibility and freedom and encourages the scientific curiosity of laboratory staff. A few of the media types started out this way. As many as 50 samples per year are analysed, including deer liver, mud puddles, snow, sea urchin and mussels.

2.17 Bore Holes

A 4L sample of water is pumped out of the bore hole into a clean polyethylene container.

A portion is removed for tritium analysis, and the remainder is acidified (15 mL of 70% nitric acid per 4 L sample). Of this, 3.6 L is measured into a marinelli beaker for gamma spectroscopy. For tritium analysis by liquid scintillation techniques, a 6 mL sample of water is counted for 100 min. For gamma spectroscopy, the sample is counted for 5000 s.

2.18 Parshall Flume

A 4L sample of water is collected by PLGS staff from the Parshall flume systems.

A portion is removed for tritium analysis, and the remainder is acidified (15 mL of 70% nitric acid per 4 L sample). Of this, 3.6 L is measured into a marinelli beaker for gamma spectroscopy. For tritium analysis by liquid scintillation techniques, a 6 mL sample of water is counted for 100 min. For gamma spectroscopy, the sample is counted for 5000 s.

2.19 Hemlock Knoll Regional Sanitary Landfill

In December 1999, PLGS began disposing of its non-active waste at the public landfill facility. A monitoring program was established prior to the first shipment. It includes sampling of water from the leachate, bore holes and various holding ponds; sampling of the soil and gamma surveys of the disposal cell surface; and dosimeter placement at key locations.

Although some extra precautions are observed due to the potential biohazard of some of these samples, they are analysed according to established procedures previously described.

Appendix C: Location Codes

A 5m	PLGS Dry Fuel Storage Facility - 5 m NNE from perimeter fence
A 10m	PLGS Dry Fuel Storage Facility - 10 m NNE from perimeter fence
A 15m	PLGS Dry Fuel Storage Facility - 15 m NNE from perimeter fence
A 20m	PLGS Dry Fuel Storage Facility - 20 m NNE from perimeter fence
A 25m	PLGS Dry Fuel Storage Facility - 25 m NNE from perimeter fence
A 50m	PLGS Dry Fuel Storage Facility - 50 m NNE from perimeter fence
A 75m	PLGS Dry Fuel Storage Facility - 75 m NNE from perimeter fence
A 100m	PLGS Dry Fuel Storage Facility - 100 m NNE from perimeter fence
A 118m	PLGS Dry Fuel Storage Facility - 118 m NNE from perimeter fence
A01R	Bocabec - Barry & Michelle Schriver
A02R	Bocabec - field across from A01R
A03R	Bocabec - inter-tidal zone
A04	Bayside - Alexander Muir (Fairmile Farm)
A05R	Letete
A06	Digdeguash
A07	Beaver Harbour
A08	Back Bay
A09	Chamcook
A10R	Grand Manan
A11	Oak Bay / Waweig

AECL	Atomic Energy of Canada Ltd., Chalk River (QA)
B 5m	PLGS Dry Fuel Storage Facility - 5 m WNW from perimeter fence
B 10m	PLGS Dry Fuel Storage Facility - 10 m WNW from perimeter fence
B 15m	PLGS Dry Fuel Storage Facility - 15 m WNW from perimeter fence
B 20m	PLGS Dry Fuel Storage Facility - 20 m WNW from perimeter fence
B 25m	PLGS Dry Fuel Storage Facility - 25 m WNW from perimeter fence
B 50m	PLGS Dry Fuel Storage Facility - 50 m WNW from perimeter fence
B 75m	PLGS Dry Fuel Storage Facility - 75 m WNW from perimeter fence
B 100m	PLGS Dry Fuel Storage Facility - 100 m WNW from perimeter fence
B 150m	PLGS Dry Fuel Storage Facility - 150 m WNW from perimeter fence
B 200m	PLGS Dry Fuel Storage Facility - 200 m WNW from perimeter fence
B01	New River Beach - inter-tidal zone
B02	Pocologan
B03	New River Beach - park
B04	New River Harbour to Pocologan Harbour
B10	Pennfield
BAXR	Baxter's Dairy
BB	PLGS - Boiler Blow-down
BD	Belledune GS
C01	Lepreau Harbour - inter-tidal zone

C03	Lepreau
CCW	PLGS – Condenser Cooling Water Duct
CH	Chatham GS
D01	Little Lepreau Basin - inter-tidal zone (remnants of clam shack)
D02	Little Lepreau
D03	Little Lepreau – Zelda McPherson
D04	Little Lepreau Basin – inter-tidal zone (remnants of boat wreck)
DH	Dalhousie GS
DOE	US Department of Energy (QA)
DUMP	PLGS – onsite landfill
DWC	PLGS – drinking water fountains
E01	Maces Bay – Floyd Small
E02	Maces Bay – Fundy Senior Citizens Centre
E03	Maces Bay – inter-tidal zone
E04	Maces Bay Cemetery
E05	Fundy Shores Elementary School – outside (Thompson/Trynor's Field)
E06	Fundy Shores Elementary School – inside
E07	Near intersection of route 790, Maces Bay Rd. and County Line Rd.
EPA	US Environmental Protection Agency (QA)
F01	Welch Cove – Dave Wright
F02	Welch Cove – inter-tidal zone

G01	Indian Cove – inter-tidal zone
G02	Point Lepreau – lighthouse
G03	offshore – within 2 km of Point Lepreau lighthouse
G04	PLGS - inter-tidal zone 1 km south of CCW out-fall
GEM	PLGS – Gaseous Effluent Monitor
GL	Grand Lake GS
H01	Duck Cove – duck pond
H02	offshore – close to PLGS condenser cooling water out-fall
H03	Duck Cove - inter-tidal zone
H04	PLGS – across the road from old site of Information Centre building
H05	PLGS - start of nature trail near old site of Information Centre trailers
HS	Hanson Stream Reservoir
I00	PLGS Solid Rad Waste Management Facility – general site area
I00A	PLGS SRWMF - south fence (east side)/Bore Hole A
I00B	PLGS SRWMF -south fence (centre) / Bore Hole B
I00C	PLGS SRWMF -south fence(west side)/Bore Hole C
I00D	PLGS SRWMF -west fence (south side)
I00E	PLGS SRWMF -west fence (centre)
I00F	PLGS SRWMF -west fence (north side)
I00G	PLGS SRWMF -north fence (west side)
I00H	PLGS SRWMF -north fence (centre)

I00I	PLGS SRWMF -north fence (east side)
I00J	PLGS SRWMF -east fence (north side)
I00K	PLGS SRWMF -east fence (centre)
I00L	PLGS SRWMF -east fence (south side)
I01	PLGS SRWMF Unit 1
I02	PLGS SRWMF Unit 2 - Dry Fuel Storage canister site
I03	PLGS Dry Fuel Storage canister site - general area
I03A	PLGS DFS - south side(next to south corner)/well #4(shallow)
I03B	PLGS DFS - south side (next to west corner) / well #4 (deep)
I03C	PLGS DFS - west corner / well #7 (shallow)
I03D	PLGS DFS - west side (next to west corner) / well #7 (deep)
I03E	PLGS DFS - west side (next to north corner) / well #6 (shallow)
I03F	PLGS DFS - north corner / well #6 (deep)
I03G	PLGS DFS - north side(next to north corner)/well #5(shallow)
I03H	PLGS DFS - north side (next to east corner) / well #5 (deep)
I03I	PLGS DFS - east corner / well #2 (shallow)
I03J	PLGS DFS - east side (next to east corner) / well #2 (deep)
I03K	PLGS DFS - east side (next to south corner) / well #3 (shallow)
I03L	PLGS DFS - south corner / well #3 (deep)
I03M	PLGS DFS - well #1 (shallow)
I03N	PLGS DFS - well #1 (deep)

I11	PLGS - woods between plant & SRWMF
I75	PLGS - north 73° east, 85 m from the stack (on pole)
I86	PLGS - 2 nd pole from SRWMF driveway heading toward outer gate
I87	PLGS - 3 rd pole from SRWMF driveway heading toward outer gate
I88	PLGS - 4 th pole from SRWMF driveway heading toward outer gate
I89	PLGS - 5 th pole from SRWMF driveway heading toward outer gate
I90	at distribution line on west side of Point Lepreau Rd.
I91	100 m north of distribution line on west side of Point Lepreau Rd.
I92	200 m north of distribution line on west side of Point Lepreau Rd.
I93	300 m north of distribution line on west side of Point Lepreau Rd.
I94	400 m north of distribution line on west side of Point Lepreau Rd.
I95	500 m north of distribution line on west side of Point Lepreau Rd.
I96	on the old Dupont warning sign at the end of the old "dynamite road"
I97	on the west side of the clearing at the end of the old "dynamite road"
I98	PLGS - north of DFS (200 m north of transmission line)
I99	PLGS - north of DFS - (100 m north of transmission line)
IAEA	International Atomic Energy Agency (QA)
J00	PLGS - south, 180 m from the stack (on fence)
J20	PLGS - south 19° east, 115 m from the stack (on fence)
J35	PLGS - south 34° east, 135 m from the stack (on sign)
J70	PLGS - south 69° east, 70 m from the stack (on pole)

K01	PLGS – 95 m west of south gate leading to the lighthouse
K02	PLGS Cooling Water Pump-house – east fence near surge shaft
K03C	PLGS sewage lagoon (chlorine contact tank)
K03E	PLGS inactive drainage (east lagoon)
K03W	PLGS inactive drainage (west lagoon)
L01	PLGS – site of old cement plant
L02	PLGS – switchyard
L03	PLGS – outer security building (main gate)
L04	PLGS – construction stores
LAB	Fredericton – Health Physics EN Laboratory (data not stored)
LEM	PLGS - Liquid Effluent Monitor
M02	PLGS – Administration Building (2 nd floor)
MQ	Mactaquac GS
N01	Dipper Harbour – Greg Thompson
N02	Dipper Harbour – Dewey Janes
N03	Dipper Harbour – Ethel Thompson
N04	Dipper Harbour – inter-tidal zone
N05	Dipper Harbour – beach behind restaurant
N06	Dipper Harbour – offshore

NTS	Nuclear Technology Services Inc. (QA)
P01	Chance Harbour
P02	Little Dipper Harbour
P03	Liberty Hill
P04	Round Meadow Farm
P05	Chance Harbour – 2 km offshore
PLGS	PLGS – general
Q01R	Lorneville
RPB	Radiation Protection Bureau, Health & Welfare Canada (QA)
S00	Saint John and surrounding area
S10	Hammond River (Mike Steele)
SPL	Spruce Lake reservoir
TAYR	Taymouth
X03R	Fredericton - Chestnut Complex lab (location for EN records storage)
X04R	Fredericton – reference seafood
X05R	Fredericton – reference milk test (B. Gay)
X10	Fredericton Junction – Atlantic Dairy Institute
Y#####	Hemlock Knoll Regional Sanitary Landfill

Appendix D: Abbreviations

<i>AECL</i>	Atomic Energy of Canada Limited
<i>CCW</i>	Condenser Cooling Water
<i>CL</i>	Critical Level
<i>CNSC</i>	Canadian Nuclear Safety Commission
<i>CSA</i>	Canadian Standards Association
<i>DEL</i>	Derived Emission Limit
<i>FWHM</i>	Full Width Half Maxima
<i>GEM</i>	Gaseous Effluent Monitor
<i>IAEA</i>	International Atomic Energy Agency
<i>LEM</i>	Liquid Effluent Monitor
<i>LLD</i>	Lower Limit of Detection
<i>LSC</i>	Liquid Scintillation Counter
<i>MSDS</i>	Material Safety Data Sheet
<i>NIST</i>	National Institute of Standards and Technology
<i>NRC</i>	National Research Council
<i>NTS</i>	Nuclear Technology Services
<i>OERMP</i>	Operational Environmental Radiation Monitoring Program
<i>OPEX</i>	Operating Experience
<i>PLGS</i>	Point Lepreau Generating Station
<i>QA</i>	Quality Assurance
<i>QC</i>	Quality Control
<i>RPB</i>	Radiation Protection Bureau
<i>SRWMF</i>	Solid Radioactive Waste Management Facility
<i>TLD</i>	Thermoluminescent Dosimeter
<i>USDOE</i>	United States Department of Environment

Appendix E: Environmental Reports Of Previous Years

PRE-OPERATIONAL (1976 - 1981)

Pre-Operational Environmental Radiation Monitoring Data for Point Lepreau Generating Station. October 1, 1976 to June 30, 1979. NBEPC-HP-79-1. J.A. Flanigan and J.J. Paciga. Sept. 1979.

Pre-Operational Environmental Radiation Monitoring Data for Point Lepreau Generating Station. January 1, 1979 to December 31, 1979. NBEPC-HP-80-1. J.A. Flanigan. Sept. 1980.

Pre-Operational Environmental Radiation Monitoring Data for Point Lepreau Generating Station. January 1, 1980 to December 31, 1980. NBEPC-HP-81-1. J.K. Sutherland and J.A. Flanigan. July 1981.

Pre-Operational Environmental Radiation Monitoring Data for Point Lepreau Generating Station. January 1, 1981 to December 31, 1981. NBEPC-HP-82-1. J.K. Sutherland. February 1982.

OPERATIONAL (1982 - 1999)

Environmental Radiation Monitoring Data for Point Lepreau Generating Station. January 01, 1982 (to 1997) to December 31, 1982 (to 1997). HP-07000-83 (to 98)-1. J.K. Sutherland. March 1983 (to 1998).

Environmental Radiation Monitoring Data for Point Lepreau Generating Station. January 01, 1998 (to 1999) to December 31, 1998 (to 1999). HP-07000-1999 (to 2000)-1. J.C. McCulley. April 1999 (to 2000).

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12. NBS Special Publication 456, *Measurements for the Safe Use of Radiation*, US Department of Commerce, 1976.
13. Cooper, E. and Cox, J., *Measurement of Low-Level Airborne $^{14}\text{CO}_2$ in the Environment Using Passive Sampling: Measurements at Canadian CANDU Sites, 1998 and 1999*, COG-00-042

Appendix G: Distribution List

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